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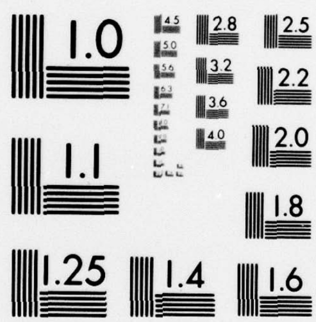

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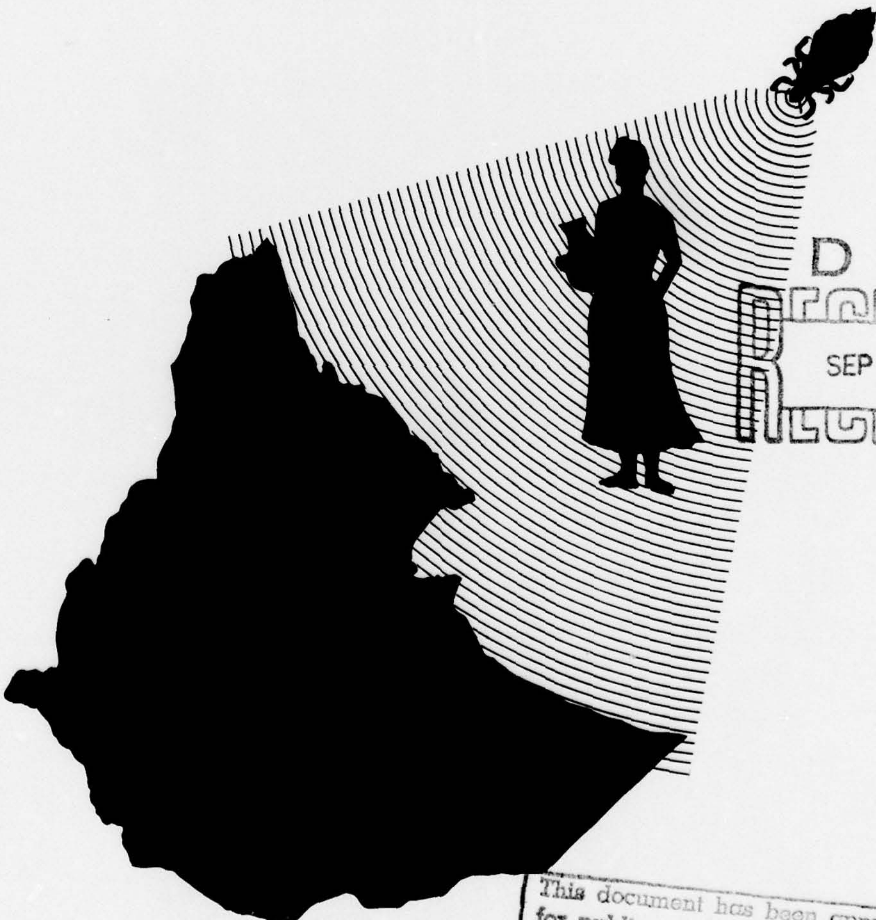

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The Epidemiology of Human Pediculosis in Ethiopia

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Jacksonville, Florida **June 1979**

Dedicated to the many Ethiopian friends, acquaintances and subjects of this study, whose cooperation, patience and hospitality not only made this research possible but also made our stay in their country a fulfilling and rewarding experience.

PREFACE

Human lice and louse-borne diseases constitute major public health problems in a number of developing countries. This includes Ethiopia which is one of the world's most important foci for louse-borne typhus and relapsing fever. During its 12 year tenure in Ethiopia, the Naval Medical Research Unit No. Five was actively involved in clinical research on louse-borne typhus and relapsing fever. Because there existed, however, a paucity of information on human louse infestations in the country, this exploratory investigation was undertaken.

Our initial objective was to gather basic epidemiological information on the distribution and density of human louse infestations within the environment of a rural developing country. The investigation was later expanded to include a description of the various physical, behavioral, cultural, and physiological factors which may influence pediculosis and louse-borne diseases.

The information resulting from this study is the most current and extensive obtained for both head and body lice from any one country. The results, therefore, will be of interest to those engaged in field epidemiology as well as medical officers, parasitologists and entomologists in the Armed Forces and the public health community. It is our hope that the experience and field techniques gained from this work in Ethiopia, a country characterized by its diversity of terrain, climate, and ethnic and cultural groups, will serve as a basis for further studies in other Third World nations. Finally, we believe that the material presented will be of practical value for organizing louse control programs during military operations and civilian control campaigns.

ACKNOWLEDGEMENTS

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The computer processing of nearly 150,000 items of information at Colorado State University was facilitated by the generous and indispensable assistance of Mr. James R. Zumbrunnen and Ms. Sara Langen. Dr. Thomas J. Keefe gave additional statistical advice in a number of areas including the linear chi-square analysis.

We should like to acknowledge the gracious assistance and valuable recommendations given by Drs. Norman G. Gratz and R. Pal, World Health Organization, which were essential elements in the development and progress of the study. Similarly, Professor James R. Busvine, London School of Hygiene and Tropical Medicine, generously shared his wealth of knowledge on human lice in the form of stimulating discussions, timely suggestions and fresh ideas.

Special recognition is due two gentlemen who provided considerable inspiration, guidance and support throughout the course of this research. CAPT Craig K. Wallace, MC, USN, former Commanding Officer of NAMRU-5, gave extensive advice regarding the collection and interpretation of clinical data while Dr. Ellicott McConnell, former Head, Medical Zoology Department of NAMRU-5, provided similar assistance with the field data. For their critical and perceptive review of data and concepts, we are most grateful.

At times, the practical difficulties encountered when conducting epidemiological research in a rural developing nation appear insurmountable. The successful completion of the research effort in Ethiopia was, in large part, a tribute to the perseverance and resourcefulness of four individuals at NAMRU-5 who were responsible for collecting and recording much of the field and hospital data. Ms. Lyn Navatkoski, Ato Negash G. Hanna, Ato Sebhatu Hailu and Mr. David J. Seibert were indefatigable workers whose enthusiasm and dedication were never dampened by adversity. Each was a vital participant in this research and to each we owe our sincere appreciation. Other individuals at NAMRU-5 who were actively involved in the investigation included: Dr. Sissay Awoke, Ato Petros W. Gabriel, Ato Mebrahtu T. Michael, Ato Waka Asfaha, Ato Aklilu Zerihun, Wz. Almaz Tekle, Ms. Joyce DeBass and Ms. Cathy Last.

We are indebted to Dr. Ellicott McConnell and Dr. John Ash for the photographs used in Figures 12 and 18, respectively. We also wish to thank Ms. Carleen Sholdt who contributed immeasurably to this work as editor, literary critic, proofreader and cheering section. Finally, we are profoundly grateful for the unfailing support and encouragement received from the Naval Medical Research and Development Command.

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INTRODUCTION

> The louse is confined, in consequence, to the increasingly diminishing populations of civilized countries who live in great distress and great poverty. But there are still many of these with us, and there are regions of the earth where life is still primitive, where bathtubs remain luxuries and bathing amounts to counterrevolution. The louse will never be completely exterminated, and there will always be occasions when it will spread widely to large sections of even the most sanitated populations. And as long as it exists, the possibility of typhus epidemics remains (Zinsser, 1935).

As Zinsser correctly predicted, the louse *(Pediculus* spp.) has not been exterminated and is, in fact, increasing in certain of the most advanced and "sanitated populations" of the world. This is evident from the increased newspaper and public health reports of head louse infestations in school children from many countries in Western Europe and North America. Relatively few current scientific accounts have been published, but those that are available indicate that the problem is becoming increasingly serious.

Louse-borne typhus and relapsing fever are two diseases which are still potential problems in large areas of the world including the more advanced nations (Wisseman, 1973). Louse-borne typhus is considered to be endemic in substantial areas of all the continents except Australia (Horwitz, 1973). The most important foci of typhus are in Africa with a majority of the cases being reported from Burundi, Rwanda, and Ethiopia. Louse-borne relapsing fever (LBRF) is reported mainly from only two countries, Ethiopia and the Sudan (Tarizzo, 1973). In 1974, an epidemic of relapsing fever was reported in a localized border area of these countries; several thousand cases occurring on the Sudan side and several hundred in Ethiopia (Perine and Reynolds, 1974). Interestingly, the danger of such an epidemic in that area had been pointed out four years earlier by Bryceson *et al.* (1970). Although Ethiopia is one of the most important foci for louse-borne typhus and relapsing fever, precise epidemiological information on the incidence of these diseases is lacking. It has been estimated, however, that over 10,000 cases of louse-borne relapsing fever (Bryceson *et al.*, 1970) and 5,000-10,000 cases of louse-borne typhus (Krause *et al.*, 1975) occur annually.

As an obligate parasite closely associated with man, the human louse is influenced more by the behavioral and physiological characteristics of its host than by the conventional population checks that affect most other animals. The volume of literature on human lice and louse-borne diseases is extraordinary. It is evident that although the biology of the human louse is relatively simple and well-studied, there is a paucity of knowledge regarding the epidemiology and population dynamics of human lice relative to their hosts. It is equally evident that such information is necessary for the effective reduction of lice and louse-borne diseases in developing countries such as Ethiopia, and for the proper management of recrudescent louse populations in the industrialized nations.

This report is primarily a descriptive epidemiological study of human pediculosis observed under conditions found in Ethiopia. Specifically, we have attempted: (1) to define the geographical distribution and prevalence of human louse infestations in selected areas of Ethiopia; (2) to describe the relative influence that certain personal, cultural, socioeconomic and physical (terrain and climate) patterns may have on louse populations; (3) to study the effects of host activity (delousing operations) on limiting the degree of infestation; (4) to determine if correlations exist between various host physiological variables and louse populations; and, (5) to identify louse-susceptible individuals and population subgroups.

REVIEW OF THE LITERATURE

Human lice are obligate blood-sucking ectoparasites belonging to the family Pediculidae. Three species are now recognized: the crab louse, *Pthirus pubis* (Linnaeus), the head louse, *Pediculus capitis* De Geer, and the body louse, *P. humanus* Linnaeus. Biologically, the principal difference between the head and body louse is in habitat. The head louse occurs primarily on the head and cements its eggs to the hair shafts. The body louse is found on the body and attaches its eggs to fibers of clothing, especially along the seams of the clothing's inner surface. The body louse feeds less frequently and is generally more robust than the head louse. The crab louse is quite distinct from the head and body louse in its appearance, habits and location. It is found principally in the pubic and perianal regions, but occasionally may occur in coarse hair on other parts of the body (Buxton, 1947; Busvine, 1966).

Although all three species are cosmopolitan in distribution, the behavioral differences between them are reflected in their relative prevalence throughout the world. Thus, the chance of becoming infested with body lice is remote for most people in the industrialized nations where clothing is washed and changed frequently. This is not the case for the head louse which has recently emerged as a significant problem in developed countries. The incidence of the crab louse is not well known, but it is considered to be much lower than for *Pediculus* spp. (Busvine, 1969).

In the laboratory, the causal organisms for typhus and relapsing fever have been shown to reproduce in both the head and body louse; however, only the body louse has been associated with major epidemics in the past and is the only proven natural vector of both diseases. Like *Pediculus* spp., the crab louse causes irritation by its bites, but its medical importance as a disease vector is limited by its sedentary habits and low rate of infestation (Busvine, 1973).

General discussions of the medical importance, biology and control of human lice can be found in Buxton (1947), Busvine (1966) and PAHO/WHO Symposium (1973). Busvine (1976) has compiled a collection of fascinating curiosities and historical references to lice and other human ectoparasites not found in other sources.

The taxonomic history and position of human lice and other Anoplura is summarized in a monograph by Ferris (1951). In a more recent study of the taxonomic status of the head and body louse, Busvine (1978) concluded they should be accorded specific rank. His conclusion was based in large part on the examination of louse specimens obtained during this investigation from Ethiopians with double infestations.

Gratz (1973) reviewed the current literature and unpublished reports to WHO and noted that surveys on body lice were generally made incidentally to other activities, such as insecticide susceptibility tests, or as follow-ups to insecticide operations after outbreaks of louse-borne diseases. He concluded that while comparatively accurate information was available on the geographical distribution of the foci and outbreaks of louse-borne diseases, little was known regarding the prevalence and distribution of body lice in these foci or elsewhere. In Gratz's opinion, this deficit in statistical information regarding body louse surveillance makes it difficult to: (1) predict the areas at risk from disease outbreaks, (2) determine if infestations are becoming widespread and (3) plan effective control measures before outbreaks occur and an emergency situation develops. The latter is of special importance since the widespread resistance of lice to insecticides

has further complicated existing problems of supplying effective lousicides for control campaigns.

Subsequent to Gratz's review, body louse infestations have been reported from a few countries. Squire (1972) noted that in Bolivia body lice were common in the cold highlands but rare in the lowlands where the changing of clothing was more frequent. In Papua, New Guinea, Bourke (1973) studied the side effects of the country's DDT malaria control program and found that reported increases in bed bugs were factual but those for body lice were not. No further data were provided. Sezi *et al.* (1972) investigated a typhus outbreak among 200 herdsmen of Rwandan origin living in two villages of the Masaka District of Uganda. Of 56 individuals examined for lice, 52 were found infested. In Egypt, Kamel *et al.*(1976) found that the prevalence of body lice averaged 65% in one village of the Fayum Governorate. Of 277 people examined from two villages in India, 9.7% of them were found with body lice (Hati *et al.*, 1974).

Compared to body lice, head louse infestations have been more thoroughly reported and information, while not adequate, is available from widely scattered areas of the world including North America. In the United States, Gorham (1975) stated that human lice (including head lice) had widespread but sporadic occurrence in Alaska, but he gave no quantitative data. In Arizona, 4.3% of 24,000 elementary children in the Tucson area were estimated to be infested with head lice (Lang, 1975). In Barrow County, Georgia, 3.0% of 1,783 elementary school children were found infested with head lice (Slonka *et al.*, 1976) while in Buffalo, New York, 7.2% of 2,650 students were infested (Slonka *et al.*, 1977). An overall estimate of the problem in the United States is given by Elzweig and Frishman (1977) who reported that between three and five million people were infested with head and pubic lice during 1976. In an area of British Columbia, Canada, 11.5% of 14,500 students were found infested with head lice. The epidemic, which lasted about six months, was the first time lice had been reported there for nearly 20 years (Hopper, 1971).

In Europe, Donaldson (1976) estimated that 2.4% or nearly 200,000 primary and secondary school-aged children in England were infested with head lice. In an overall assessment for Britain, Andrews (1977) believed that one and a half million people were harboring human lice. A 1971 report from the Danish Pest Infestation Laboratory maintained that head louse incidence in Denmark was increasing significantly (Gratz, 1973). In Germany, Gromzig (1971) found that 4.7%, 11.8% and 8.6% of Berlin school children were infested with head lice for the years 1966, 1967 and 1968, respectively. In Wroclaw, Poland, 1.5% of 93,379 school children were found infested with head lice (Chylak *et al.*, 1967). Nearby in Czechoslovakia, 4.1% of 4,374 school children were found infested with head lice (Palicka *et al.*, 1971). In the same country, Pazdziora (1971) observed head lice on 19.6% of pupils attending special schools.

In Israel, Lidror and Lifshitz (1965) reported a head louse infestation rate of 30.1% for 4,216 children examined from four villages inhabited by the indigenous population. Jafayer (1967) examined 2,649 people from ten villages in Shiraz, Iran and found 30.9% with head lice. Nearby in India, 41.3% of 277 people examined from two villages were found infested (Hati *et al.*, 1974).

In New Zealand, Andrews (1976) noted that while body lice were rare, head louse infestations had increased especially in school children. In Malaysia, 29.6% of 361 primary school children (aged 6-7 years) were found with head lice (Chen and Dugdale, 1972).

For South America, Schenone *et al.* (1973) reported 25.9% of 53,556 persons (mostly school children) examined in Santiago, Chile, were found infested with head lice. Later, 24.9% of 25,413 children from Santiago public primary schools were found infested (Lolio *et al.*, 1975). Squire (1972) noted that head lice were common in the highlands and lowlands of Bolivia but gave no further data.

At a 1973 PAHO/WHO symposium, Traub (1973) stated:

> Since lice are the ectoparasites most intimately associated with humans, it is

> not surprising that man's beliefs, customs, and practices affect the distribution and incidence of louse-borne diseases more than they do many other infections.

Gaon (1973), at the same symposium, discussed various socioeconomic factors that influence the spread and maintenance of lousiness in certain areas and stressed that effective louse control was not possible if these factors remained unrecognized. Kim (1973) recommended a holistic or systems approach to louse eradication by considering climatic, culture, economic and biological factors influencing both the host and the louse. Earlier, Buxton (1938, 1941a, 1941b, 1947) emphasized the need to conduct comprehensive surveys for head, body and crab lice on a number of different individuals; to study louse prevalence as related to social, religious, cultural and anthropological factors; and to investigate seasonal differences in louse prevalence, particularly in those areas experiencing a high prevalence of louse-borne diseases.

In our review of the literature dating back to the late 1880's, fewer than 60 published accounts were found which studied in some way the host factors mentioned above. Most of these papers only briefly mentioned an overall infestation rate; some considered additional personal factors such as age and sex, but only a relatively few discussed the epidemiology of human pediculosis in any depth.

Early studies on head louse incidence involving rather large populations include those of Greenough (1887) and Sobel (1913) in the United States, and those of Mellanby (1941, 1943) in England prior to and during World War II. Two other notable studies conducted in England are those of Mellanby (1942b), who correlated head louse prevalence with family size, and Rollin (1943) who found head lice to be more prevalent among less intelligent W.A.A.F. recruits, Chylak *et al.* (1967, 1970) studied certain familial, social, economic and hygienic factors in relation to head louse prevalence in Poland, but the populations involved were relatively small. Lang (1975) studied head louse infestations in Tucson, Arizona, and reported observations relative to several different socioeconomic factors. The studies by Slonka *et al.* (1976, 1977), in Georgia and New York, are the most recent and most complete.

Buxton (1936, 1938, 1940b, 1941b) studied over 3,700 crops of hair sent to him from six locations in Asia and Africa and determined the number of lice in relation to age, sex, race, season of the year and to hair length. These studies are of special interest because they are the only extensive investigations on lice in developing countries. Although he found some significant associations with the factors studied, Buxton concluded that such work could be better accomplished by an investigator situated in the country itself.

The increase in head louse prevalence in the industrialized nations has been attributed to a combination of factors including changes in personal hygiene habits among certain subcultures and a gradual increase of insecticide resistance. The specific causes, however, remain unclear because of the lack of extensive epidemiological investigations (Gratz, 1973).

In France, Nicoli and Sautet (1955) and Sautet and Aldighieri (1959) studied the frequency of body lice in different groups but few statistics are given. Gratz (1973) observed that there is little epidemiological information on body louse infestations throughout the world and especially in developing countries.

> He [the body louse] lives, blissfully irresponsible, like the Polynesians before the advent of Captain Cook, roaming on the land of plenty, where nature provides warmth, shelter, the odors he loves best, copses for love, and secure undergrowth to which his chosen mate can attach her nest. Under his feet is an inexhaustible supply of the food he prefers, and he has but to sink his hollow stylet into a tender skin to procure his two or three daily meals, with much less trouble than it takes the aborigines to knock a coconut off a tree. In his unrestrained simplicity, he is much like Rousseau's noble savage,

— so abhorrent to Mr. Babbitt, — leading a physically and emotionally unrestricted life (Zinsser, 1935).

Compared to most other insects, the human louse does appear to lead a unique existence since food competition, varying climatic conditions, predation and parasitism have little apparent effect in regulating its populations (Busvine, 1973). Based on life tables constructed by Buxton (1947), one would expect frequently to find large populations of lice numbering in the hundreds or thousands. Such heavy infestations are considered a rarity by Busvine (1966) who considered the principal checks on population growth to be the delousing operations of man himself. He further suggested that the efficiency of these operations would depend on the individuals' personal hygiene standards, on the facilities available and on the hosts' sensitivity to louse bites.

Buxton (1947) believed that a large proportion of louse morbidity was due to human interference (such as combing, hand picking, washing and laundering clothes) and that death from old age, predators or parasites was rare. He suggested that such action against lice had two characteristics:

1. Man does not act regularly, killing a small proportion daily: on the contrary, he selects a particular day for washing his shirt or taking some other sort of drastic action. The mortality that he produces is therefore exceedingly irregular.
2. On the whole, man's activity will be more intense as the population of lice rises, so that the mortality produced will tend to be a function of the density of population.

There is little quantitative information regarding louse population dynamics as related to host activity or self-grooming methods, and these may be of epidemiological significance. During a period that typhus and relapsing fever were epidemic, Buxton (1947) wrote of observing workmen sitting on top of a wall in Iran, picking off lice and dropping them into the street below!

While the efforts of man to rid himself of lice are generally believed responsible for keeping populations in check, there appears to be other factors that may also be important but are not well understood. Buxton (1938) raised some intriguing questions when he stated: "It is evident that there must be a very large amount of *individual* difference to account for the fact that at the same place and season and within the same age-group, sex, etc., one observes great differences in the infestation of different human beings." Later, he suggested: "It seems probable that lice establish themselves more readily on one man than another, though it would be difficult to prove this" (Buxton, 1947).

Buxton (1938) believed that individual differences were due to many different causes:

1. There must be much variation among normal healthy people.
2. The probability of being infested, and heavily infested, will be increased by disabling conditions, long illness, destitution, feeble-mindedness, etc.
3. An individual's vanity, indifference, etc. will affect his chance of becoming and remaining infested.
4. Individual preference and local customs in the manner of hair-cutting and hairdressing, the use of cosmetics, etc., must be a factor of considerable importance.

Hase (1915b) studied about 1,000 individuals and their sensitivity or reaction to louse bites and noted that there were those who never became lousy although they lived among those that were. During insecticide resistance studies on body lice in Queenstown, South Africa, a Bantu woman who cared for and slept with a louse infested invalid was never found to be lousy herself (Steyn *et al.*, 1960). In their studies on natural populations of body lice, MacLeod and Craufurd-Benson (1941) observed that nymphs and adults failed to establish themselves on one particular individual even though there was evidence of exposure to continuous infestations. Moore and Hirschfelder (1919) reported that, of the subjects used in feeding louse colonies, lice would not feed on one particular individual but merely wandered about on his arm. They fed readily, however, when transferred to his brother or to other

subjects. This apparent aversion of the lice to feed could not be explained. Jackson and McMurtry (1912) stated that individuals vary in their susceptibility to head lice but offered no further explanation. In a rather amusing account, Foot (1920) mentioned that lice reared on a French sailor became pugnacious after each meal or refused to feed at all. She attributed this phenomenon to some abnormal condition of the subject's blood; possibly due to the influence of drugs. Of historical interest, Darwin (1895) made the following statement:

> The surgeon of a whaling ship in the Pacific assured me that when the Pediculi, with which some Sandwich Islanders on board swarmed, strayed on to the bodies of the English sailors, they died in the course of three or four days.

Hopkins (1949) believed there was direct evidence for human individual insusceptibility although this was rare. But among other mammals there might be instances where it was the rule, or even universal; possibly playing a major role in the extinction of lice from certain groups of hosts. He did not offer any explanations for the possible causes of insusceptibility to louse infestations in man.

Physiological variations in people and their differences in attractiveness to blood-sucking insects has been little studied except in mosquitoes (Gilbert *et al.*, 1966; Maibach *et al.*, 1966; Wood *et al.*, 1972; Wood, 1974, 1975, 1976; Wright, 1975; Thornton *et al.*, 1976).

Nelson *et al.* (1975, 1977) discussed the state-of-the-art of host-ectoparasite relationships including spatial distribution on hosts, effects of host nutrition and endocrine state on the parasite, pathogenesis, immunologic phenomena, and native and acquired resistance. Despite a considerable amount of previous work, the authors believed that the investigation of host-ectoparasite interactions was a frontier field. Much current knowledge on the subject has been based on studies of host-parasite systems involving small laboratory animals or limited populations of livestock animals. Only a few studies were cited by the authors in regard to human hosts and their ectoparasites, including lice. A review of selected investigations on animals is of interest for it may provide possible avenues of approach in human studies.

Murray (1961), Bell *et al.* (1962), and Bell and Clifford (1964) found that grooming was a major factor in determing louse burdens in white mice although Bell *et al.* (1966) stated that other factors such as acquired resistance were also involved. Lewis *et al.* (1967) reported that populations of the long-nosed cattle louse increased on cattle restrained from self-grooming. Differences in louse populations in Hereford cattle were reported to be due to poor nutrition which reduced self-grooming activity and impeded shedding of coats (Utech *et al.*, 1969). For animals in general, Nelson *et al.* (1977) stated that the first line of defense against ectoparasite burdens was the hosts' grooming response.

Based on laboratory studies, rats deficient in certain vitamins were believed to be predisposed to increased pediculosis (Gyorgy, 1938; Searls and Snyder, 1939; Gyorgy and Eckardt, 1940). Kartman (1942, 1943, 1949) concluded from his own studies, however, that vitamin deficiencies were not the major factor governing resistance in rats to lice, but that interrelated effects of both nutrition and host activity (self-grooming) were responsible. In a review of these studies, Buxton (1947) was of the opinion that observations in rats had little relevancy to lousiness in humans and that the administration of vitamin pills would not necessarily benefit lousy men. He also maintained that lousiness in domestic animals of poor health and badly fed may not be the result of malnutrition but that the two may both follow neglect.

Nelson *et al.* (1972) described skin changes which occurred in white mice following louse infestations. These changes resulted in reduced parasite burdens similar to those following sheep ked infestations (Nelson and Bainborough, 1963). Vitamin A deficiency in cattle has been reported to cause certain skin alterations which predispose the animals to increased invasion by larvae of *Hypoderma lineatum* (Gingrich and Barrett, 1975). Similar observations have not been made in humans, although Buxton (1940a) noted that first stage louse nymphs had more difficulty in feeding from the bare skin of certain individuals than others.

According to Nelson *et al.* (1975), the distribution of ectoparasites on the surface of their host may be restricted by such host factors as self-and mutual grooming, thickness of skin, hairiness, atmospheric conditions and host resistance. Nutritional deficiencies of the host may also affect the ectoparasites through physical changes in the skin substrate from which they obtain food. Such changes may facilitate feeding of the parasites resulting in increased populations or prevent it, resulting in reduced or eliminated populations; or the changes may have no effect at all. The authors conclude, however, that there is a deficit of knowledge regarding the host-parasite interface.

In Holstein cattle, a positive association was found between hair diameter and louse populations (Gojmerac *et al.*, 1959). Hocking (1957) suggested that hair diameter was an important factor in host selection by lice as their claw size was related to the diameter of their host's hair. Ashcroft (1969) studied head lice in Guyanese children and found that children of East Indian origin were infested but not those of African origin. Since housing, family and social factors for both groups were similar, he concluded that the oval cross-sectional shape of African hair was less favorable to head lice than the round shape of East Indian hair.

Allen and Dicke (1952) reported that clipping the hair of cattle would control chewing lice although it was somewhat less effective against sucking lice. In the United Kingdom, Asian immigrants had a much lower prevalence of crab lice in comparison to indigenous persons. This was attributed to the fact that Asians regularly shave their pubic and axillary regions (Fisher and Morton, 1970). Busvine and Reid (1949) noted that in Malaya, head lice were less prevalent in Chinese than in Indians and Malayans. They believed this was due in part to the Chinese habit of keeping their children's head hair cut short.

After successfully adapting body lice to rabbits, Culpepper (1948) found considerable variation between individual rabbits as to their suitability as hosts. Of 97 rabbits tested, only seven proved favorable. No explanation for this phenomenon was given. In a more recent study, body lice were found to demonstrate interesting differences in their ability to feed and survive on seven different nonspecific hosts including rats, guinea pigs and chickens. The variation in suitability of these substitute hosts could not be explained by their systematic relationships (Ludwig, 1973).

STUDY AREA

Ethiopia, the oldest independent country in Africa, is located in the Northeast portion of the Continent known as the Horn (Fig. 1). Roughly triangular in shape, the country is divided into 14 provinces that encompass nearly 1,222,000 km^2. Ethiopia shares frontiers with Somalia, Kenya, Sudan and Djibouti, and its Northeastern coastline extends along the Red Sea.

The major topographical features of the country are a massive highland complex of mountains and plateaus cleft diagonally, from northeast to southwest, by the Great Rift Valley. This vast massif, comprising nearly two-thirds of the land, rises like an island from the surrounding plains; abruptly and almost perpendicular. The highest point of the massif is Mount Ras Dashen (4,620 m). In the Plains, the lowest point is the Danakil depression which is in places 100 m below sea level.

The country's varied climatic conditions reflect its geographical location and diverse topography. At 3° north to 18° north latitude, Ethiopia lies well within the Torrid Zone. But the altitude of the highland complex gives most of the country a temperate climate which varies little throughout the year. In striking contrast, the eastern lowlands are equatorially hot and dry while the western river basins are usually hot and humid. Temperatures range from near freezing in the Afro-alpine zones to nearly 50°C in the hot zone along the Red Sea coast. However, most of the country enjoys the cool and salubrious temperatures of 15-30°C in the temperate zone of the highlands.

Ethiopia has pronounced wet and dry seasons which are often of uncertain duration and vary in different parts of the country. In the Central Highlands, including the capital Addis Ababa, the rainy season extends from mid-June to mid-September preceded by intermittent showers in February or March. Annual rainfall levels vary considerably from less than 50 mm at Assab near the Red Sea coast to more than 2100 mm in the southwestern highland region near Gore.

As one might expect, the vegetation zones of Ethiopia are also variegated. While temperate or tropical grasslands occur in most of the country, the natural flora is diverse and ranges from Afro-alpine and deciduous forests to savanna and thorny subdesert scrub.

The rugged highland terrain and long rainy season have been among the major factors limiting the transportation facilities in Ethiopia. All-weather travel is possible on only about one-third of the 24,000 km network of public roads and tracks. Away from the major roads, transportation is generally by mule, donkey or camel caravan. In recent years, surface transportation has been improved by the operation of an interurban bus line. In addition, a domestic airline provides passenger and cargo service to over 40 towns and cities; many in relatively isolated rural areas and with unimproved runways. Nearly half of the population lives more than one days walk from an all-weather road, and access to many areas is possible only by horseback, on foot, by dugout canoe, by "bush" plane or helicopter.

Although an accurate census has never been taken, the population of Ethiopia is believed to approach 30 million making it one of the most heavily populated nations in Africa.

Like their country, Ethiopians are ethnically heterogeneous and divided into many different tribes and peoples. Most have Caucasian features and relatively light skin, although some negroid and dark-skinned types exist, especially in the southwestern regions. An estimated 95 languages and dialects are spoken, the majority of which are

Figure 1. Map of Ethiopia showing its position in Africa and provincial borders.

of Semitic and Cushitic origin. Of the more than 60 different ethnic groups, the Galla, Amhara and Tigre together comprise more than three-fourth's of the population. Generally, most of the Central and Northern highlanders are Ethiopian Orthodox Christians (35-40%); Muslims mainly inhabit the eastern coastal regions (40-45%) while a variety of tribal religions persist in the southern and western regions.

Ethiopia ranks among the poorest and most underdeveloped nations in the world with a per capita income of about $90 a year and an illiteracy rate of more than 90%. A vast majority of the people live in miserable conditions, dependent

upon a traditional and inefficient agricultural system. In recent years, the serious lack of food and water has produced widespread famine and disease.

Ethiopia is predominantly a rural agricultural nation with 90% of its population engaged in some form of cultivation, animal husbandry, or both. Small subsistence farming is dominant in the highlands while nomadic pasturing is characteristic of the lowlands. Although the methods of cultivation are primitive by Western standards, Ethiopia is nearly self-sufficient in agricultural produce. The principal export crop is coffee. Livestock and good grazing land are plentiful and, next to coffee, cattle-raising probably has the greatest economic potential. Industrial activity is limited primarily to the processing of natural products.

The bulk of the population is concentrated in the highlands while the lowlands are inhabited primarily by nomadic tribes. As the population is predominantly rural, the urban areas tend to be mostly extended villages or market towns. These are characterized by a small core of permanent residents, augmented by numerous migrants and visitors during harvests, festivals and market times. A few modern and Western-style dwellings may be found in some sections of the larger cities. However, most traditional dwellings, called "tukuls," conform to a common and primitive architectural style: circular with mud walls, a conical grass-thatched roof and an earthen floor. There is one low door but usually no windows.

The national dress is the "shamma," a white, toga-like garment about 1.5-3.0 m long which is wrapped around the shoulders by both men and women. Underneath, the men wear cotton trousers, white jodhpurs or khaki shorts while the women wear one-piece, long-sleeved dresses with gathered skirts. Western-style clothing has become increasingly popular but most of the people continue to dress in the traditional manner.

The public health problems and diseases found in Ethiopia are discussed in depth by Schaller (1972), who concluded that Ethiopia was probably unmatched among tropical countries in its abundance of pathology. Malaria and tuberculosis are major endemic diseases. Venereal diseases, including syphilis, are widespread. Leprosy is common in certain areas. Parasitic diseases, including schistosomiasis, leishmaniasis, filariasis and onchocerciasis, are major public health problems. Infectious eye diseases, gastroenteritic infections, typhoid, typhus and relapsing fever are also prevalent.

The country's health problems are aggravated by the limited availability of public health facilities and manpower; made worse by traditional practices of insanitation, nutritional deficiencies and limited economic resources. Modern sewage and waste disposal facilities and potable water supplies are unknown to most of the population which neither understands the concepts of public health nor has access to modern medical facilities. It relies instead on the ministrations of traditional curers. While a network of public health centers and rural clinics is planned, only a small portion of the country is currently furnished with these facilities. In a recent paper, Conacher (1976) traces the development of health services in Ethiopia and reviews the current status of medical care delivery.

In geographical, ethnic and tropical disease diversity, Ethiopia seems to distinguish itself from the rest of Africa. The vast and widespread number of diseases associated with this diversity has prompted Schaller (1972) to suggest: "It appears that no other country in Africa is more suited for geomedical analyses of disease occurrence than Ethiopia."

Selected references which describe Ethiopia and its peoples in more detail include: Pankhurst (1968), Kaplan *et al.* (1971), Levine (1972) and Ullendorff (1973).

SUBJECTS AND METHODS

This investigation was conducted in Ethiopia during the period of January 1974 to July 1976 under a medical entomology research program of the Naval Medical Research Unit No. Five (NAMRU-5). The investigation comprised two main projects: a hospital study of 386 volunteer subjects and a field study involving 5,492 individuals.

NAMRU -5

The US Navy established NAMRU-5 in 1965 for the primary purpose of conducting research and development on infectious diseases of military importance in sub-sahara Africa. Prior to its closure in 1977, the Unit was staffed with some 20 US personnel and 60 Ethiopians.

The base laboratory in Addis Ababa (altitude 2285 m, average barometric pressure 582 mm Hg) included parasitology, bacteriology and clinical laboratories which provided support for a modern 22 bed clinical research unit in adjacent St. Paul's Hospital. These facilities and their personnel were used extensively in this investigation.

NATIONAL SURVEY

A nationwide survey was carried out to establish the overall distribution and density of human louse infestations and to identify any areas of particular prevalence. A total of 49 towns and villages in the 14 provinces of Ethiopia were visited during the study. Most of these communities were located in the highland area of the country where a major portion of the rural population is concentrated. An attempt was made, however, to survey those areas which would provide a cross-section of all geographical regions of Ethiopia, including sites near border zones where frequent migrations occur from neighboring countries.

Final selection of the areas visited was largely determined by their accessibility by Land Rover or domestic airline service. Certain remote areas were reached by private, single engine planes flown by chartered "bush" pilots. A few isolated villages in Illubabor province were reached by foot or dugout canoe. Visits at all locations were usually 5-7 days in duration.

Initially, the surveys were conducted at schools, churches, markets, prisons, medical facilities or individual dwellings (Fig. 2). By trial and error, however, it became evident that the most effective investigative approach was to work through the regional health centers or rural clinics when available. The medical environment of these facilities gave the people confidence and improved their cooperation. In addition, it allowed for privacy both while conducting interviews and while examining clothing and hair for lice.

An effort was made to obtain equal representation from male and female adults and children. The choice of individuals which could be examined, by circumstance, varied from place to place.

At each location, tribal, political, religious and medical officials (who often controlled public opinion) were contacted and briefed about the purpose of the survey. This action usually enhanced the cooperation of the populace in the surveys.

A majority of the persons examined were well; their participation elicited by giving each one a small bar of American hand soap — a luxury in all areas — and, in some instances, a small can of insecticide dust or a bottle of insect repellent. Minor injuries were treated by a Navy paramedic

Figure 2. Head louse survey in a small Amhara village outside of Addis Ababa, Ethiopia.

at locations where no local medical assistance was available.

Even within the environment of a medical facility, conducting clothing examinations often necessitated compromise as to the extent to which some individuals, especially women, would disrobe to have their clothing examined. In these difficult cases, only areas of the clothing most likely to be infested were checked. (For example, rolling down the waist band of the trousers and checking the seams of a shirt, blouse, dress or underclothes). After some experience, the degree of infestation could be reasonably estimated.

Head louse infestations were assessed by using the fingers to part the hair while checking for nits and crawling stages. Special attention was paid to areas where infestations most often occur such as around the ears and the nape of the neck.

The surveys were usually conducted by a team of two people, at least one of whom was able to speak the principal language of the region. One team member conducted an interview and completed a pre-coded questionnaire (Appendix Fig. 1) similar to that used in the hospital study. The second team member examined the clothing and hair, assessing louse numbers. Under this cooperative effort, subjects were usually processed within 10-15 minutes.

LONGITUDINAL STUDY

A longitudinal study was conducted in Addis Ababa to determine if seasonal changes occurred in louse populations. Using the examination procedures discussed above, about 100 different persons were examined monthly for 24 months. Most of the subjects were seen at the Municipal Clinic; a free-care facility located near the center of the capital city. This medical facility was selected as

a sampling point for similar reasons as outlined above in the national survey. LBRF cases diagnosed at this clinic were also recorded.

To minimize observer error, the field teams were trained in the techniques of interview research and the use of the questionnaire (Appendix Fig. 1). Supervision was also provided during the course of the field survey work to reduce significant variations in the procedures used from standards established initially. The unique considerations and difficulties in planning and conducting survey research in a rural developing country have been reviewed in detail by Pausewang (1973) and are not further discussed here.

HOSPITAL STUDY

Patient Selection

Patients selected for the hospital study were acquired from a variety of sources within Addis Ababa including the Mercato (market), churches, transient hotels and other areas where indigent and migrant persons congregated seeking food, shelter and employment.

Healthy Ethiopians within the lower socioeconomic level appeared to be suspicious and afraid of the modern medical facilities in Addis Ababa and many refused to have their blood drawn (believing that blood lost could not be regenerated) or to submit to other clinical tests. Such difficulties are not unusual in developing countries and have been observed elsewhere (Barker, 1976). A majority of the patients examined were obtained, therefore, from the Municipal Clinic — this facility received 4,000-5,000 outpatients a month and was found to be a ready source of suitable subjects who, being sick, were cooperative and amenable to investigation.

It was difficult to find non-lousy and relatively healthy individuals from the above sources who would be suitable as control subjects. Therefore, 210 individuals were included in the study from the following sources: Domestic servants employed within the foreign community, students from the local nurse's school, the staff of St. Paul's Hospital, and local-hire employees of the American Embassy and NAMRU-5.

Individuals consenting to treatment and investigation were admitted to the NAMRU-5 ward at St. Paul's Hospital. Upon admission, a complete history and physical examination was performed by one of three physicians who recorded pertinent observations upon an examination checklist (Appendix Fig. 2) and a standard summary form (Appendix Fig. 3). Volunteers admitted to the ward were examined at least once daily by a physician and were cared for by nurses trained in research procedures (Fig. 3).

Physiological Tests and Measurements

A cross-sectional medical study including over 50 hematological, biochemical and other clinical tests were carried out on the volunteer subjects and recorded on a standard coded form (Appendix Fig. 4). The tests are summarized below:

Clinical Characteristics. Body temperature (rectal), pulse and blood pressure, and chest X-rays were taken, and a TB Tine test administered.

Hematology. Tests included hemoglobin, hematocrit, reticulocyte count, red blood cell count, mean corpuscular hemoglobin concentration, mean corpuscular volume, mean corpuscular hemoglobin, white blood cell with differential count, platelet count, prothrombin time and partial thromboplastin time, blood group and type.

Urinalysis. Conventional methods were used in assessing urine pH, specific gravity, glucose, protein and white blood cells.

Blood Chemistry. Tests and methods included postprandial blood sugar, blood urea nitrogen, creatinine, alkaline phosphatase, serum glutamic oxaloacetic transaminase, serum glutamic pyruvic transaminase, bilirubin (total and direct), cholesterol, sodium, chloride, calcium, phosphorus, potassium, carbon dioxide, serum protein and serum protein electrophoresis.

The hematological, urinalysis and blood chemistry tests generally followed the procedures outlined by Davidsohn and Henry (1974) and Tietz (1976). Most have also been described earlier in studies done at NAMRU-5 by Bryceson *et al.* (1970). The specific tests and methods used are summarized in Appendix Table 1.

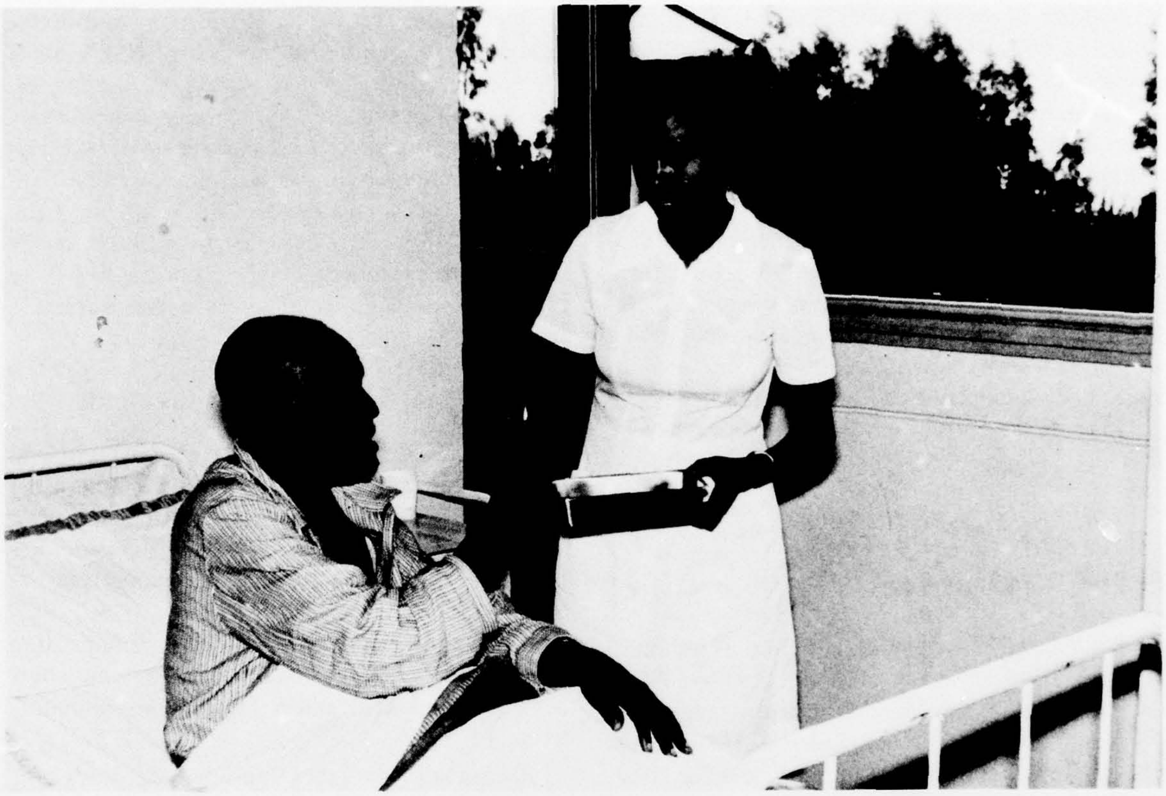

Figure 3. Medical research-trained nurse caring for a convalescent relapsing fever patient.

Parasitology. Fecal samples were taken and examined for ova and parasites using Merthiolate-Iodine-Formaldehyde (MIF) and MIF Concentration methods (Sapero and Lawless, 1953; Blagg *et al.*, 1955). Malaria smears involved preparation of thick and thin blood films which were Giemsa-stained and read under a compound microscope. In suspect relapsing fever cases, peripheral blood smears were read under phase contrast light and *Borrelia* spirochete density estimated using the method of Bryceson *et al.* (1970).

Anthropometric Measurements. Patient weight and height were assessed using Detecto balance beam scales with a linear measurement device. Arm circumference was measured on the mid-upper, right arm using a flexible, non-stretch tape. Using Harpenden calipers, skinfold thickness was assessed from the right aspect of the body for the biceps, triceps and subscapular area (Fig. 4).

Skin pH/Temperature. As recommended by Behrendt and Green (1971), the mean pH of the skin surface was measured from exposed or open skin sites. Three body regions were sampled (posterior neck, anterior abdomen, inner upper right thigh) using a Markson Electro-Mark pH meter with a flat electrode. Mean skin temperature was measured at the same sites using a Markson Digital Thermometer with a YSI series Banjo probe.

Sweat Chlorides. Relative sweat rate was measured using an Orion Research Incorporated Model 417 Skin Chloride System (Fig. 5). The procedure employed the pilocarpine iontophoresis, sweat-stimulation method as a test for sweat chloride concentration (Kopito and Shwachman, 1969).

Skin Microflora. Skin surface flora was investigated qualitatively using the swabbing method (Fig. 6). Swabs from three body sites (as for skin pH) were inoculated in peptone water and

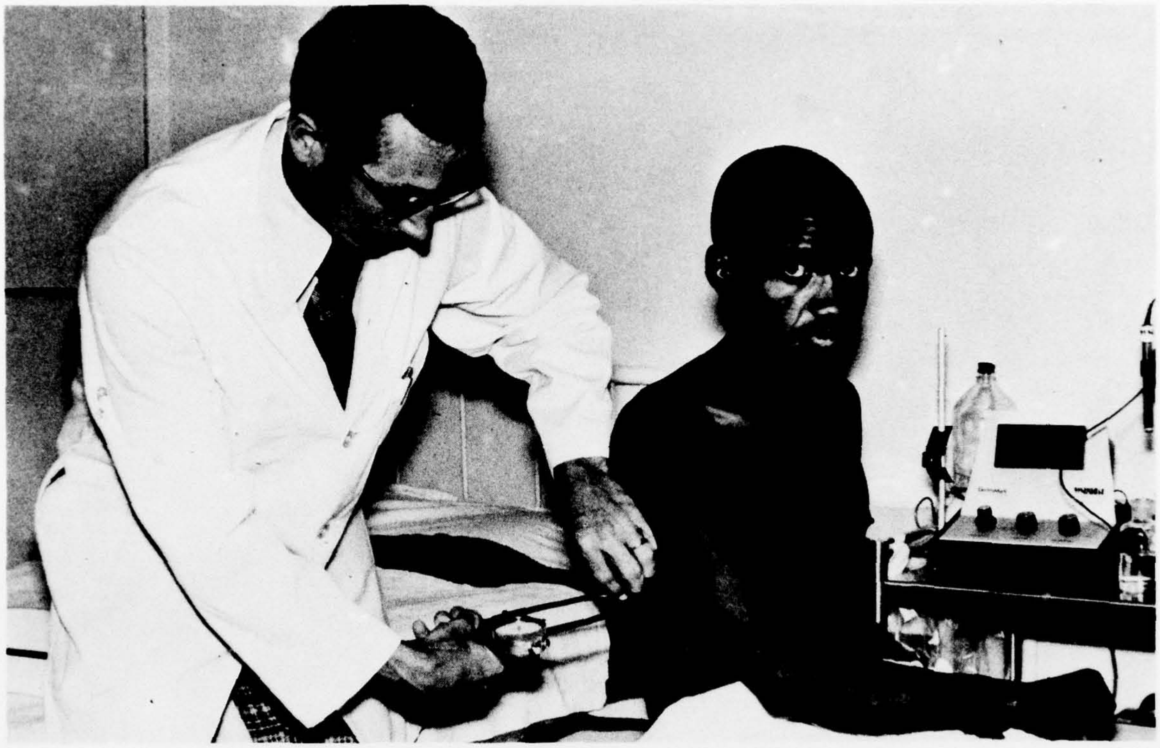

Figure 4. Measuring subscapular skinfold thickness using Harpenden calipers.

incubated in an atmosphere of 10% CO_2 and O_2 for 24 hours at 37°C. Organisms were isolated on blood agar and MacConkey agar plates. Identifications were made using Difco differential media. Specific techniques and methods used at NAMRU-5 have been discussed by Perine *et al.* (1975).

The anthropometric measurements and skin tests (microflora, pH, temperature) were taken soon after the patient was admitted to the NAMRU-5 ward and prior to bathing. The blood, urine and stool specimens, and sweat chloride measurements were normally taken on the same day of admission after the patient had been bathed and secured in bed. Exceptions were outpatients such as the control subjects who were processed in 2-4 hours on one day. The ambient temperature on the NAMRU-5 ward floor averaged 21-23°C during the study.

To reduce technician variability, most of the anthropometric measurements and skin samples were accomplished by the same individual. The NAMRU-5 clinical and bacteriological laboratories participated in quality control programs of the Center for Disease Control and the American College of Pathology for defining and limiting analytical variations.

Personal Interview

Prior to discharge from the NAMRU-5 ward, each subject was interviewed by a team of two persons in a similar manner as for the field surveys (Fig. 7). A standard questionnaire completed (Appendix Fig. 5) included questions related to various personal attributes, socioeconomic status, general living conditions, personal hygiene habits, and pesticide exposure. Additional information was obtained concerning the use of body or hair dressings, the use of plant material as a louse toxicant, efforts to eliminate lice mechanically or by physical destruction and, finally, customs, folklore or superstitions concerning lice and louse-borne diseases.

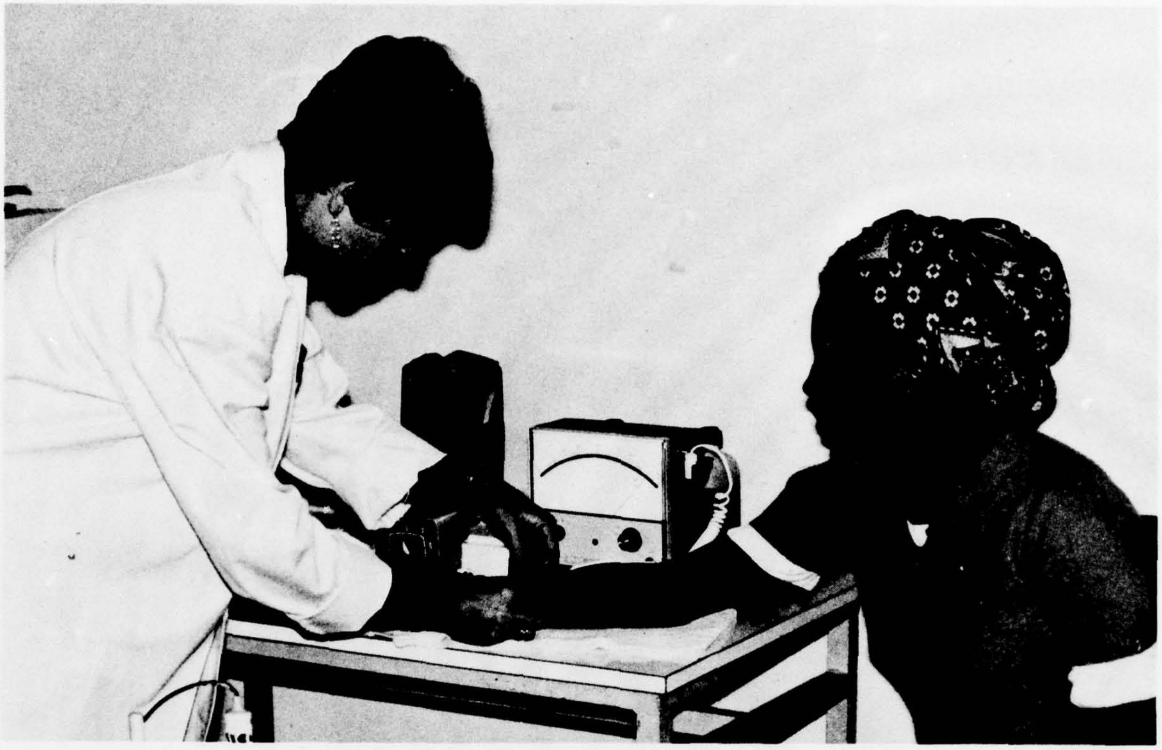

Figure 5. Determining sweat chloride concentration as a measure of relative sweat rate using an Orion Research Incorporated Model 417 Skin Chloride System.

Louse Counts

Human louse numbers and related data were assessed and recorded on a standard form (Appendix Fig. 6) following the procedure outlined below:

The subject's clothing was removed and the different articles stored separately in plastic or paper bags. The location and number of eggs, nymphs and adult body lice were assessed and recorded for each article of clothing (Fig. 8). In cases of large numbers of lice (>100), the lice were brushed from the clothing into a plastic container; divided into smaller batches and counted in petri dishes. The presence of other ectoparasites such as fleas or bed bugs was also recorded.

Using a millimeter rule, hair shafts were measured from the crown, temporal and occipital areas of the head. Hair length was estimated as an average of these measurements. The general condition of the hair and location of nits and crawling stages was also noted.

The head was shaved using electric clippers; the hair collected from an enamel pan and stored in a plastic bag. The weight of the hair crop was determined using a Mettler Company Model P1200 electronic balance. The diameters of ten hair shafts were measured under an American Optical compound microscope using an ocular micrometer scale.

Employing a procedure adapted from Buxton (1936), each hair crop was dissolved in a boiling solution of sodium sulfide (Fig. 9). Adults and nymphs, which remain undissolved, were recovered and counted using a pipette and hand counter.

Finally, the axillary, pubic and perianal areas of the body were examined for crab lice. The numbers and locations of any found were recorded.

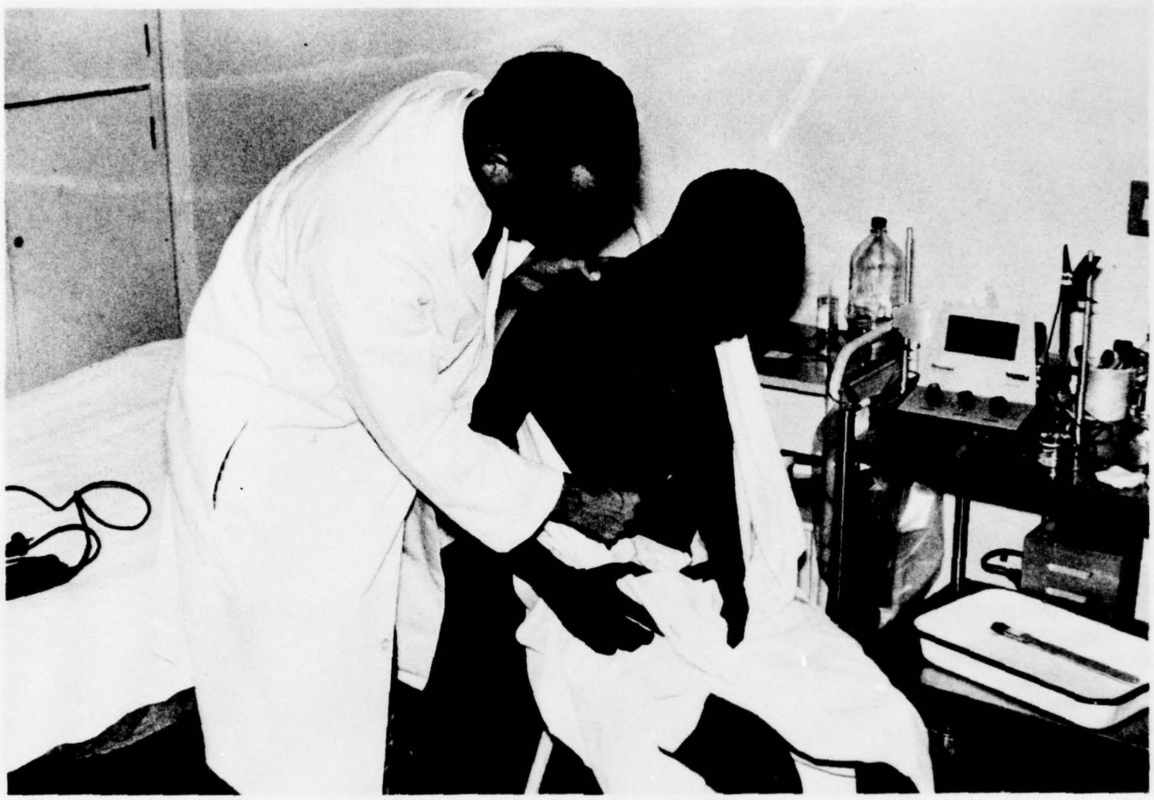

Figure 6. Swabbing skin for qualitative sample of bacteria microflora.

Figure 7. Interpreter and entomologist interviewing a volunteer patient for pertinent epidemiological information.

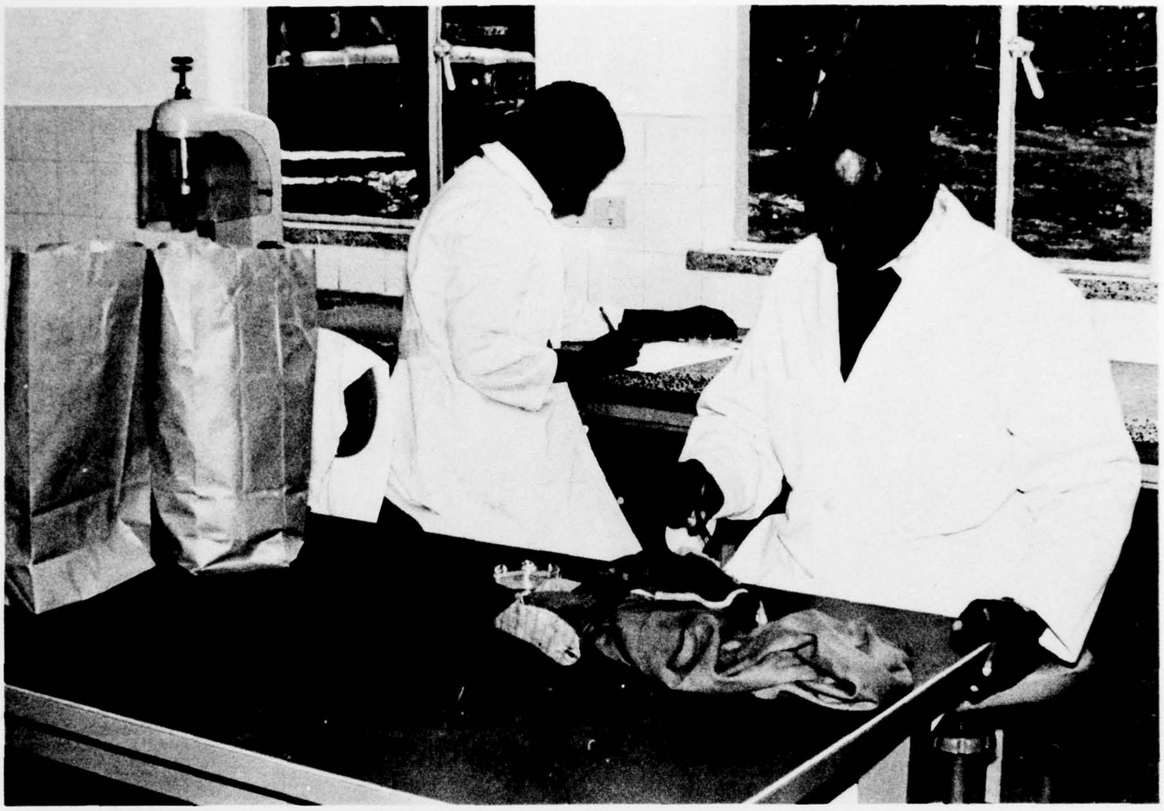

Figure 8. Assessing body louse numbers in the clothing of a hospital patient.

DATA ANALYSIS

Results of the hospital study and field surveys were summarized and coded, then transcribed to computer cards and magnetic tapes. Data analysis was accomplished on a CDC 6400 Computer at Colorado State University using the Statistical Package for the Social Sciences (SPSS); a packaged program specifically designed for the analysis of social science data (Nie *et al.*, 1975). SPSS subprograms (in capital letters) used in the data analysis are described below:

FREQUENCIES — Computes one-way frequency distribution with descriptive statistics.

CROSSTABS — Computes n-way crosstabulation tables giving a joint frequency distribution of cases and contingency table statistics including chi-square.

BREAKDOWN — Calculates and prints sums, means, standard deviations and variances of dependent variables among subgroups.

T-TEST — Computes Student's t and probability levels for sample means.

PEARSON CORR — Computes Pearson product-moment correlation coefficients for pairs of interval-level variables.

SCATTERGRAM — Prints a two-dimensional plot of data points for the two variables considered and computes related linear regression statistics.

REGRESSION — Computes multiple regression analysis.

ANOVA — Performs one-to five-way analysis of variance and covariance for factorial analysis.

ONEWAY — Performs one-way analysis of variance. Duncan's multiple range test included as a subsidiary statistic for some problems.

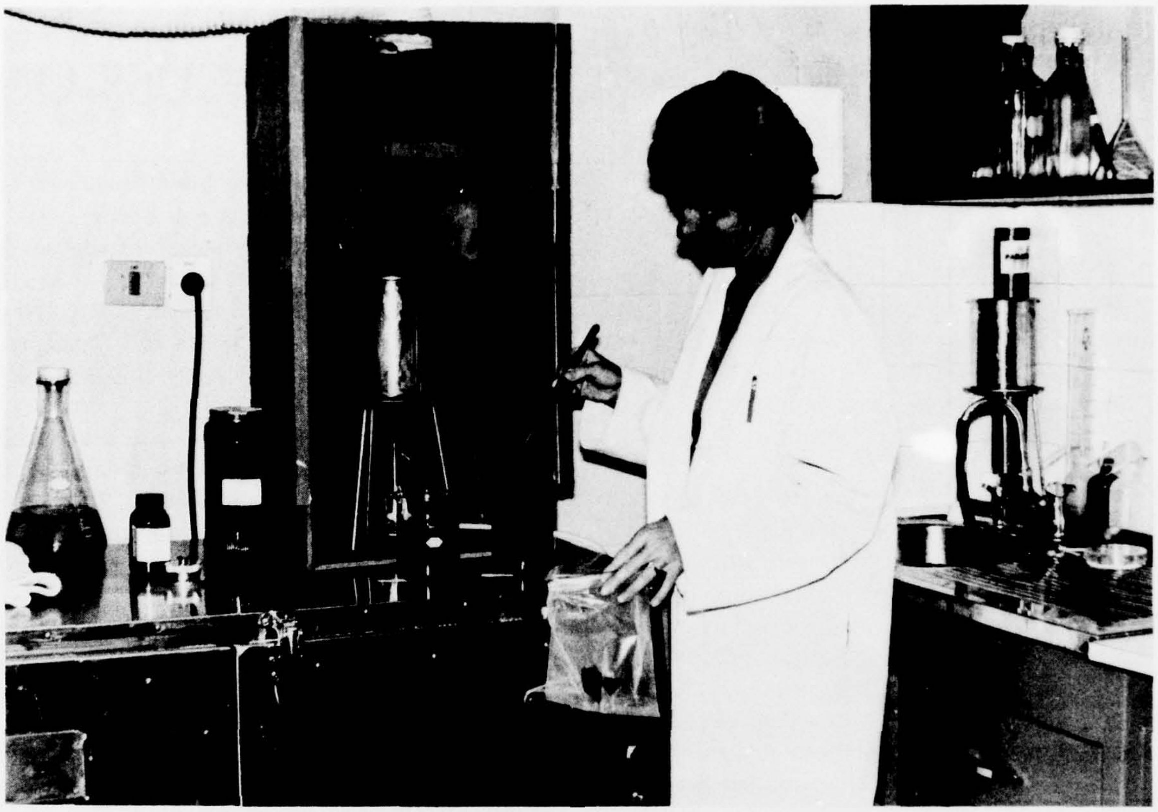

Figure 9. Processing a crop of hair to determine the number of head lice present.

Potential linear relationships between louse levels and ordinal data such as age and education level were determined using a chi-square test for linearity proposed by Cochran (1954) and developed by Fleiss (1973).

The standard error for quantal data (expressed as a percentage) was determined using the method described for example by Kilpatrick (1977).

Head and body louse counts from some individuals in the study included unusually large values which would inflate arithmetic means. Therefore, a logarithmic transformation, $\mathrm{Log}_{10}\,(n+1)$, was applied to the data and louse counts were reported as geometric means (Williams, 1937).

Displays of data and tests for significance include variations in population size since individuals with missing data were excluded.

RESULTS AND DISCUSSION

NATIONAL SURVEY

A total of 3,133 persons in 49 towns and villages (Fig. 10) were examined during the national survey. Included were 698 inmates of 23 central and district prisons. Because of the distinctly different and controlled environment under which the prisoners lived, their results are presented separately.

Selected personal characteristics of the subjects examined have been summarized for non-prisoners (Appendix Table 2) and prisoners (Appendix Table 3). Included in these summaries are the median age and sex ratios for each community along with the predominant ethnic group and religion, and the frequency with which clothes were washed. The frequency with which clothes were changed was not included since this information was not available for many of the locations. Appendix Table 4 lists the province for each location, estimates of the population, elevation, mean temperature and precipitation.

Populations at the different locations were difficult to assess since a detailed and reliable census had not been done in Ethiopia. The figures shown in Appendix Table 4 are based on those provided by local governmental officials and from other sources (Kaplan *et al.*, 1971; Wolde-Mariam, 1972). While useful for comparative purposes, the figures listed may be affected by such factors as seasonal migrations, festivals, market times and, recently, by the political and social upheaval occurring throughout much of the country. Population figures for the prisons visited could not be obtained.

Of the 49 communities, 12 had populations of 10,000 or more while 14 had populations under 1000. The latter were mostly rural villages in remote areas accessible only by Land Rover (during the dry season), by bush plane or by foot. Rural migrants and visitors along with prisoners made up a significant portion of the samples from the larger towns, such as Asmara, Dire Dawa, Harar and Gondar. It was not, therefore, considered necessary to analyze them separately from the more rural locations.

Elevation figures were based on data available from the Meteorological Office in Addis Ababa and from other sources (Kaplan *et al.*, 1971; Wolde-Mariam, 1972). In certain remote locations, elevation was determined from airplane or hand-held altimeters.

A network of meteorological observation stations is widely spaced throughout the country, but coverage is generally inadequate and detailed summaries of climatic conditions were available only from a few of the major towns and villages. For some locations, mean annual temperature and precipitation figures were based on those available from the nearest observation station in an area with similar altitude and geographical features. Supportive meteorological data were obtained from Kaplan *et al.* (1971), Schaller (1972) and Wolde-Mariam (1972).

A correlation coefficient matrix for the climatic and personal hygiene factors was calculated. As anticipated, lower temperatures and greater precipitation correlated with increased altitude. No correlations were detected between the frequency with which clothes were washed and either elevation or the climatic factors. The above analysis did not include locations with sample sizes under ten.

The prevalence and density of body lice were higher on prisoners (Tables 1 and 2) than on non-prisoners (Tables 3 and 4) and both were reversed for head lice.

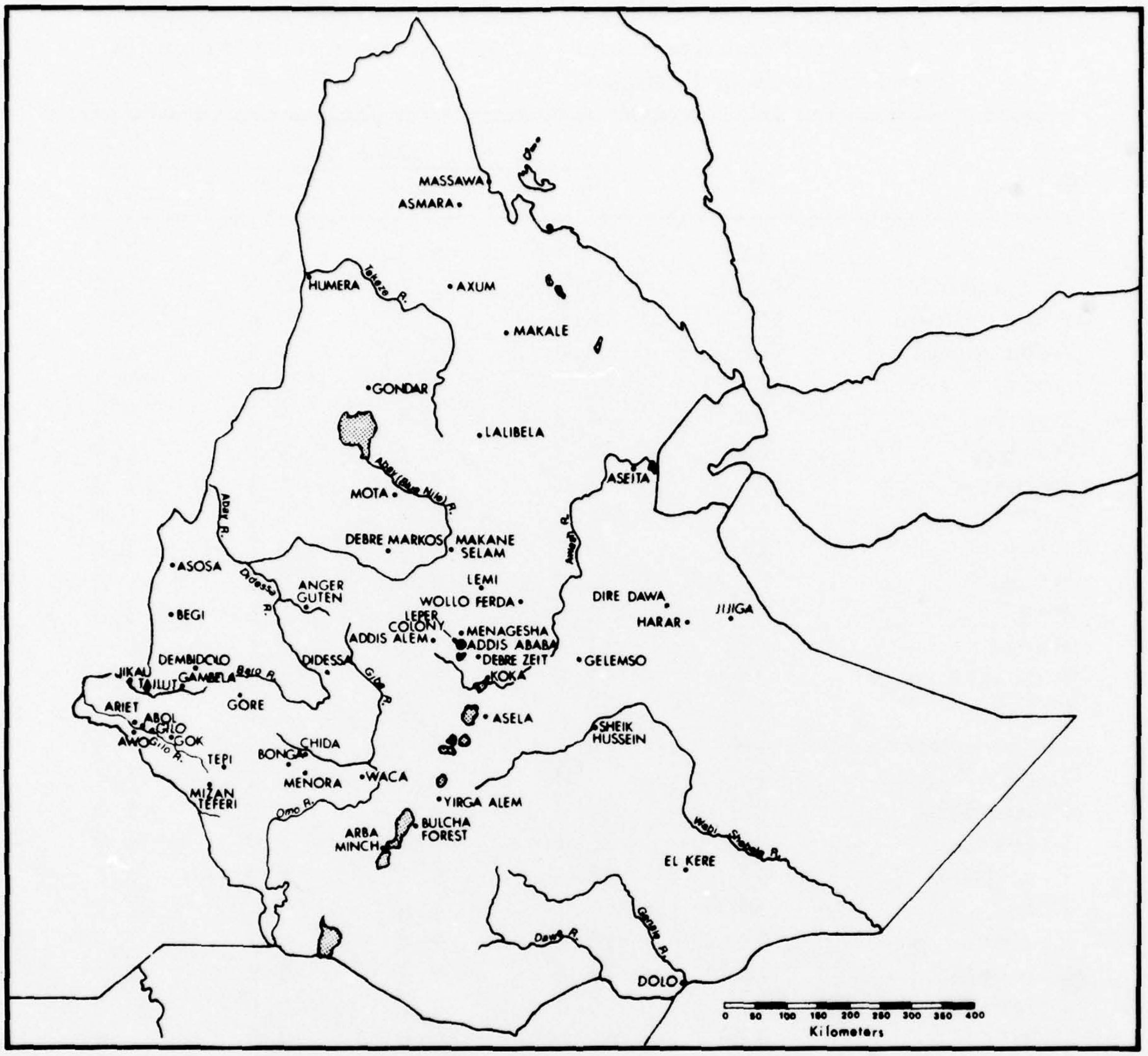

Figure 10. Map of Ethiopia showing the location of 49 towns and villages involved in a nationwide epidemiological survey.

The prevalance and density of lice were found to be closely associated. For non-prisoners, a positive correlation was found between the proportion of individuals infested with body lice and density of infestations ($r=0.64$, $P \leq 0.001$). A correlation coefficient calculated beween head louse prevalence and density was also positive and significant ($r=0.81$, $P<0.001$). Similar results were obtained for prisoners. The above evidence agrees with limited observations which have been made for head lice (Buxton, 1938).

No obvious linear relationship was found in scattergrams plotting louse prevalence and density against age and sex ratios for each community. Similarly, there were no obvious relationships detected between pediculosis and the predominant ethnic group or religion at each location. Of the various factors considered, infrequent clothes washing was found to be the most significantly associated with lousiness.

Table 1. Percentage prevalence (%) and geometric mean (GM) levels of head lice found on 2435 persons from 49 towns and villages in Ethiopia.

Town	N	Head Lice %	SE	GM	SD
Abol	29	86.2	6.4	4.1	2.4
Addis Alem	110	19.1	3.8	0.3	1.9
Anger Guten	113	16.8	3.5	0.6	3.9
Arba Minch	89	3.4	1.9	0.1	1.4
Ariet	23	95.7	4.2	2.9	2.1
Aseita	69	4.3	2.4	0.1	1.4
Asela	33	21.2	7.1	0.2	1.6
Asmara	36	8.3	4.6	0.1	1.2
Asosa	73	24.7	5.0	0.3	1.8
Awo	21	90.5	6.4	3.7	3.1
Axum	89	30.3	4.9	0.3	1.4
Begi	69	53.6	6.0	1.6	3.2
Bonga	74	1.4	1.4	0.1	1.3
Bulcha Forest	29	27.6	8.3	1.2	4.3
Chida	26	46.2	9.8	2.3	5.9
Debre Markos	79	20.3	4.5	0.3	1.9
Debre Zeit	94	7.4	2.7	0.1	1.4
Dembidolo	80	21.2	4.6	0.2	1.7
Didessa	194	36.1	3.4	1.7	4.2
Dire Dawa	50	38.0	6.9	1.9	4.1
Dolo	30	6.7	4.6	0.1	1.2
El Kere	29	13.8	6.4	0.1	1.5
Gambela	72	13.9	4.1	0.2	1.5
Gelemso	4	0.0	0.0	0.0	0.0
Gilo	22	45.5	10.6	0.6	1.9
Gok	21	52.4	10.9	0.4	1.4
Gondar	66	3.0	2.1	0.1	1.1
Gore	95	10.5	3.2	0.4	3.1
Harar	49	55.1	7.1	3.6	4.6
Humera	13	7.7	7.4	0.1	1.2
Jijiga	46	41.3	7.3	2.3	4.5
Jikau	31	38.7	8.8	0.5	1.9
Koka	31	35.5	8.6	0.9	3.6
Lalibela	65	21.9	5.1	0.2	1.3
Lemi	18	38.9	11.5	2.0	4.2
Leper Colony	28	50.0	9.4	3.5	6.0

Table 1. Continued.

Town	N	Head Lice %	SE	GM	SD
Makale	73	17.8	4.5	0.3	2.3
Makane Salem	30	80.0	7.3	6.8	4.0
Massawa	6	0.0	0.0	0.0	0.0
Menagesha	3	66.7	27.2	8.9	8.1
Menora	26	26.9	8.7	0.2	1.4
Mizan Teferi	30	0.0	0.0	0.0	0.0
Mota	44	18.2	5.8	0.3	2.0
Sheik Hussein	31	22.6	7.5	0.3	1.8
Tailut	19	0.0	0.0	0.0	0.0
Tepi	68	4.4	2.5	0.1	1.5
Waca	65	7.7	3.3	0.2	1.8
Wollo Ferda	10	10.0	9.5	0.2	1.8
Yirga Alem	30	53.3	9.1	0.9	2.8
Total	2435	24.4	0.9	0.6	2.7

Table 2. Percentage prevalence (%) and geometric mean (GM) levels of body lice found on 2435 persons from 49 towns and villages in Ethiopia.

Town	N	Body Lice %	SE	GM	SD
Abol	29	58.6	9.2	1.9	3.0
Addis Alem	110	53.6	4.8	4.2	5.0
Anger Guten	113	76.9	4.0	6.9	3.2
Arba Minch	89	64.0	5.1	4.4	4.1
Ariet	23	47.8	10.4	1.7	3.3
Aseita	69	14.5	4.2	0.5	3.0
Asela	33	36.4	8.4	1.0	3.4
Asmara	36	38.9	8.1	1.8	4.0
Asosa	73	39.7	5.7	1.3	3.3
Awo	21	81.0	8.6	4.5	3.3
Axum	89	61.8	5.2	2.9	4.4
Begi	69	55.1	6.0	4.7	6.3
Bonga	74	79.7	4.7	9.8	4.1

Table 2. Continued.

Town	N	Body Lice %	SE	GM	SD
Bulcha Forest	29	86.2	6.4	11.1	3.5
Chida	26	84.6	7.1	41.9	8.3
Debre Markos	79	65.8	5.3	2.8	3.1
Debre Zeit	94	43.6	5.1	2.3	4.4
Dembidolo	80	76.3	4.8	23.4	7.4
Didessa	194	64.9	3.4	9.7	6.5
Dire Dawa	50	52.0	7.1	7.1	8.9
Dolo	30	23.3	7.7	0.2	1.5
El Kere	29	17.2	7.0	0.5	2.8
Gambela	72	31.9	5.5	0.4	1.9
Gelemso	4	100.0	0.0	331.8	1.4
Gilo	22	36.4	10.3	0.5	1.8
Gok	21	14.3	7.6	0.2	1.7
Gondar	66	59.1	6.1	4.1	5.2
Gore	95	35.8	4.9	2.9	7.2
Harar	49	61.2	7.0	10.7	8.9
Humera	13	38.5	13.5	1.7	3.8
Jijiga	46	65.2	7.0	11.1	7.4
Jikau	31	71.0	8.1	1.5	2.3
Koka	31	80.6	7.1	9.7	4.3
Lalibela	65	76.6	5.3	6.0	5.6
Lemi	18	94.4	5.4	23.7	3.0
Leper Colony	28	78.6	7.8	20.0	7.5
Makale	73	82.2	4.5	30.1	7.4
Makane Selam	30	80.0	7.3	25.5	7.1
Massawa	6	16.7	15.2	0.9	4.6
Menagesha	3	100.0	0.0	27.6	3.1
Menora	26	65.4	9.3	3.5	4.4
Mizan Teferi	30	36.7	8.8	3.4	8.5
Mota	44	90.9	4.3	18.4	5.0
Sheik Hussein	31	77.4	7.5	3.9	2.9
Tailut	19	78.9	9.4	1.1	1.9
Tepi	68	69.1	5.6	12.3	7.6
Waca	65	44.6	6.2	3.8	7.2
Wollo Ferda	10	60.0	15.5	2.9	3.4
Yirga Alem	30	70.0	8.4	8.3	7.5
Total	2435	59.1	1.0	5.0	6.1

Table 3. Percentage prevalence (%) and geometric mean (GM) levels of head lice found on 698 prisoners from 23 towns in Ethiopia.

Town	N	Head Lice %	SE	GM	SD
Arba Minch	40	0.0	0.0	0.0	0.0
Asela	27	29.6	8.8	0.2	1.4
Asmara	59	40.7	6.4	0.9	2.8
Asosa	46	2.2	2.2	0.1	1.1
Axum	15	0.0	0.0	0.0	0.0
Begi	22	13.6	7.3	0.4	2.3
Bonga	49	0.0	0.0	0.0	0.0
Debre Markos	30	10.0	5.5	0.1	1.5
Debre Zeit	6	0.0	0.0	0.0	0.0
Dembidolo	34	2.9	2.9	0.1	1.6
Gambela	42	2.4	2.4	0.1	1.1
Gelemso	31	0.0	0.0	0.0	0.0
Gondar	9	0.0	0.0	0.0	0.0
Gore	29	24.1	7.9	1.5	5.4
Humera	39	30.8	7.4	0.3	1.6
Jijiga	31	54.8	8.9	3.4	4.5
Makale	20	0.0	0.0	0.0	0.0
Makane Selam	41	0.0	0.0	0.0	0.0
Massawa	23	0.0	0.0	0.0	0.0
Mizan Teferi	26	0.0	0.0	0.0	0.0
Mota	22	0.0	0.0	0.0	0.0
Waca	53	0.0	0.0	0.0	0.0
Yirga Alem	4	0.0	0.0	0.0	0.0
Total	698	11.0	1.2	0.2	2.0

Correlation coefficients were calculated between louse prevalence and density, elevation, climatic factors and clothes washing frequency (Tables 5 and 6). Locations with sample sizes under ten were not included in the analysis. For non-prisoners, body louse prevalence and density showed a positive correlation with elevation and negative correlations with temperature and clothes washing frequency. Interestingly, body louse prevalence in prisoners showed a similar association with nearly the same coefficients for elevation, temperature and clothes washing frequency; the conditions of the prisons apparently not influencing these factors to a signficant extent. The only significant correlation found for head lice was between head louse prevalence and clothes washing frequency in non-prisoners. This association may be explained on the basis that those individuals

Table 4. Percentage prevalence (%) and geometric mean (GM) levels of body lice found on 698 prisoners from 23 towns in Ethiopia.

Town	N	Body Lice			
		%	SE	GM	SD
Arba Minch	40	77.5	6.6	11.5	6.0
Asela	27	100.0	0.0	16.5	4.3
Asmara	59	74.6	5.7	18.7	7.4
Asosa	46	65.2	7.0	3.2	3.6
Axum	15	60.0	12.6	1.4	2.8
Begi	22	45.5	10.6	4.0	6.5
Bonga	49	95.9	2.8	28.7	2.6
Debre Markos	30	46.7	9.1	1.3	2.7
Debre Zeit	6	100.0	0.0	46.6	1.8
Dembidolo	34	88.2	5.5	48.9	7.6
Gambela	42	76.2	6.6	3.2	3.3
Gelemso	31	83.9	6.6	38.1	6.4
Gondar	9	88.9	10.5	28.4	7.9
Gore	29	68.9	8.6	14.4	7.8
Humera	39	87.2	5.4	23.2	4.0
Jijiga	31	70.9	8.2	20.1	9.8
Makale	20	80.0	8.9	19.8	6.0
Makane Selam	41	82.9	5.9	49.1	8.2
Massawa	23	4.3	4.2	0.1	1.9
Mizan Teferi	26	38.5	9.5	1.8	3.9
Mota	22	100.0	0.0	5.7	2.4
Waca	53	94.3	3.2	22.5	4.3
Yirga Alem	4	100.0	0.0	335.5	2.2
Total	698	75.5	1.6	12.2	6.8

who washed their clothes frequently also practiced better overall personal hygiene. No significant correlations were found between precipitation and pediculosis in either non-prisoners or prisoners.

There was no significant relationship found between clothes washing frequency and elevation. The association between lousiness and increased elevation was presumably due, therefore, to individuals wearing more clothing in the higher altitudes and a greater tendency for them to huddle together for protection from the lower temperatures.

In India, Hati *et al.* (1974) examined 277 persons in two villages located at altitudes of 1,859 and 3,109 meters, respectively. Prevalence of both head and body lice was greater in the village at the higher elevation. Poor personal hygiene and

Table 5. Correlation coefficients of percentage prevalence (%) and geometric mean (GM) levels of human lice, and selected physical and personal hygiene data for 46 towns and villages in Ethiopia.

	Elevation			Rainfall[a]			Temperature[a]			Freq. Clothes Washed[a]		
Variable	N	r	P<	N	r	P<	N	r	P<	N	r	P<
% Body Lice	46	.39	.004	46	.16	NS	46	-.43	.001	46	-.58	.001
GM Body Lice	46	.40	.003	46	.08	NS	46	-.43	.001	46	-.27	.035
% Head Lice	46	-.14	NS	46	-.11	NS	46	.21	NS	46	-.32	.016
GM Head Lice	46	.06	NS	46	-.11	NS	46	.03	NS	46	-.21	NS

[a]Mean annual figures

Table 6. Correlation coefficients of percentage prevalence (%) and geometric mean (GM) levels of human lice, and selected physical and personal hygiene data for 20 prison locations in Ethiopia.

	Elevation			Rainfall[a]			Temperature[a]			Freq. Clothes Washed[a]		
Variable	N	r	P<	N	r	P<	N	r	P<	N	r	P<
% Body Lice	20	.40	.042	20	.04	NS	20	-.41	.035	20	-.57	.004
GM Body Lice	20	.22	NS	20	-.17	NS	20	-.21	NS	20	-.05	NS
% Head Lice	20	.07	NS	20	-.24	NS	20	.14	NS	20	.28	NS
GM Head Lice	20	-.01	NS	20	-.06	NS	20	.25	NS	20	.23	NS

[a]Mean annual figures

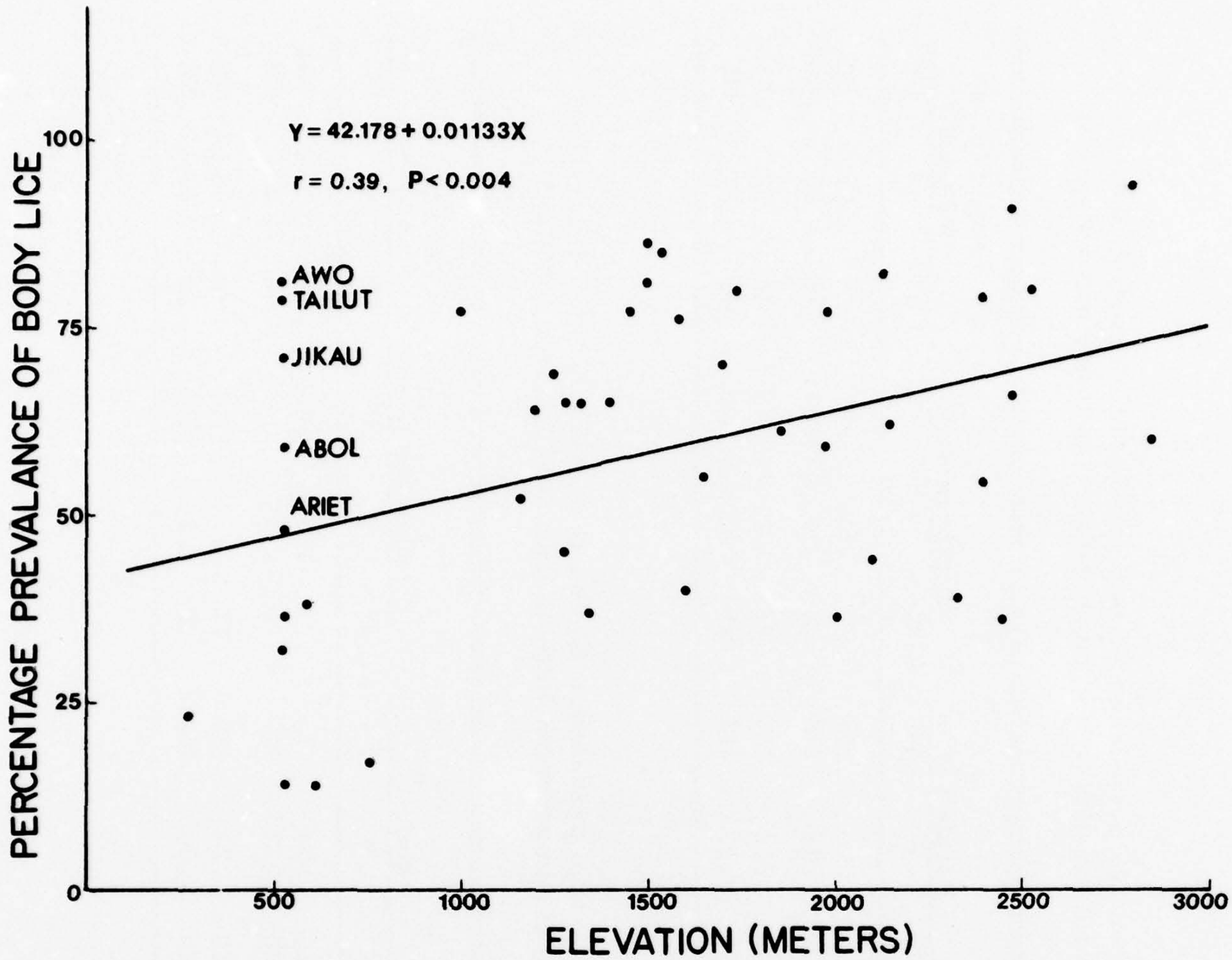

Figure 11. Relationship between percentage prevalence of body lice and elevation for 46 towns and villages sampled in the national survey. Five lowland villages with comparatively high body louse prevalence are identified.

an apparent lack of concern for their lousy condition was reportedly the same for the people in both villages. Nuttall (1917) reported that body lice occurred in the colder parts of India but that head lice were found in both the cold and hot areas. Anderson and Goldberger (1910) observed louse-borne typhus cases on the Plateau (> 1500-1800 m) in Mexico, but not at lower altitudes. Body louse infestations were reportedly rare at Tampico (located on the Gulf Coast) although head lice were common. Actual numbers of lice involved in these reports were not given.

High relative humidity adversely affects the life span and reproductive capacity of lice, and this has been suggested as a possible influence on the area distribution of human lice (Culpepper, 1946; Smith, 1973). For those few locations for which data were available, we could find no clear association between relative humidity and pediculosis.

Figure 11 shows the relationship between elevation and body louse prevalence for 46 communities (non-prisoners). Of interest are the five points at 530 m elevation showing comparatively high body louse prevalence. These five points represent the lowland villages of Abol, Ariet, Awo, Jikau and Tailut which are located on the Baro and Gilo Rivers near the Sudan border in

Illubabor province. This finding is of epidemiological importance in relation to relapsing fever epidemics which occurred recently in that region.

A louse-borne relapsing fever outbreak involving several thousand cases on the Sudan side and several hundred in Ethiopia started in July 1974, around the Lakes District of southern Sudan and spread eastward into the lowlands of southwestern Ethiopia; an area free of the disease at the time (Perine and Reynolds, 1974).

In February 1976, the American Presbyterian Mission reported 35 deaths in a number of Anuak villages along the Gilo River near the Sudan border and 130 km west of Gilo Village. These deaths were attributed to louse-borne relapsing fever (Reimers, 1976) and NAMRU-5 confirmed *Borrelia* spirochetes in blood films taken from victims in the area. During the same month, at least two cases of relapsing fever were diagnosed by the American Presbyterian Mission clinic at Pokow; a village located 29 km west of Gambela and also on the Baro River.

Based on informal reports to NAMRU-5, this outbreak apparently began in mid-December 1975, and ended in mid-February 1976; a period when politically motivated and seasonal migrations from the Sudan probably occurred. Anuaks referred to the outbreak as the "louse disease" (Reimers, 1976), presumably because of their recent experience with LBRF. Unfortunately, further details on the morbidity and mortality from the disease were not available because of the remoteness of the villages and the lack of medical services in the region.

The region is populated primarily by Nuers and Anuaks of Nilotic origin. Casual movement occurs throughout the area and the bordering Sudan, particularly during the dry season. A fairly well-defined wet and dry season occurs with most of the rain falling between April and September. December and January are the driest months while February through April are usually the warmest. The landscape in the region varies from flood plain to savanna woodland and gallery forests. A full description of the area and its people is provided by Hutchinson (1971).

A louse survey was completed in July 1974, at Gambela, located a few kilometers east of the outbreak area. Forty Anuaks and Nuers were examined in Gambela, some of whom were migrants from the southwestern region of Illubabor province. Of these, twenty were infested with body lice but densities were low ($\bar{x}=1.4$ lice, range= 1-12 lice).

A survey of the villages actually located in the outbreak area was conducted in early March 1976, to gather further information on pediculosis. In the Nuer villages of Tailut and Jikau, the people were found to be mostly naked except for married women who wore only a loincloth. Clothes such as shorts, shirt or a simple cotton dress were borrowed or exchanged with friends when visiting another village or going to market. Of interest was the widespread practice of covering the body with ashes which was said to provide protecion from mosquito attacks. The effect, if any, on louse infestations was unknown.

In the Anuak villages of Abol, Ariet and Awo, the men wore simple shorts and shirt while the women wore a loincloth or a cloth wrapped around the waist. Children were usually nude. At night, the Anuaks wrapped themselves up in a "sleeping cloth" or blanket for sleeping. As for the Nuers, clothes were shared with each other.

In both tribes, body lice were found in the clothes and blankets which were stored in their huts during the daytime. The numbers of lice found were low, ranging from 1-5 per article. Body lice and nits were also found in beads and giraffe hair necklaces such as those worn by women and children (Fig. 12). Similar observations have been made for other tribes in Africa (Brumpt, 1949; Fabrikant, 1973). Of the 123 persons examined in the five villages, 66.7% were infested with body lice while 63.4% were infested with head lice. Mean levels of infestation were low ($\bar{x}=4.2$ body lice, range= 1-35; $\bar{x}=3.7$ head lice, range= 1-30 lice).

The Nuers and Anuaks are particularly social people who are in frequent and intimate contact during the day as they drink their locally made beer or smoke their gourd water pipes, and at night while sleeping. Exchange visits with relatives and friends are common and may involve journeys on foot of more than 150 km. On such occasions, the visitor is hospitably received and welcomed to sleep in the host's hut. Young men,

Figure 12. Anuak girls in the Gilo River area of Illubabor province where recent epidemics of relapsing fever have occurred. Beads and giraffe hair necklaces were found infested with body lice and nits.

in particular, congregate and sleep together in bachelor huts and are usually the most mobile of the population. When a person is sick or dying, his friends and relatives will congregate inside his hut to offer their sympathy and condolences. Gear *et al.* (1944) believed that similar native customs, involving intimate contact and traveling long distances, were to blame for the spread of louse-borne typhus in the Transkei even though actual louse numbers were quite low.

Abdalla (1969) studied a LBRF outbreak among immigrants from the Upper Nile province in Sudan and reported that although the people were not very lousy, lice were always found in bedding and a small number in the clothing they wore. Gear *et al.* (1944) studied typhus in the Transkei and reported that body lice were difficult to find. They believed that once the disease was widespread, a large number of lice was not required to maintain transmission.

Clinically, LBRF and tick-borne relapsing fever (TBRF) are not readily differentiated (Felsenfeld, 1971), and it is unknown what involvement, if any, TBRF may have had in the outbreaks of 1974 and 1976. Schaller (1972) stated that the tick vectors, *Ornithodoros moubata* and *O. savignyi* occur in Ethiopia. He noted, however, that in Ethiopia little data were

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available on the incidence of TBRF and that the occurrence of the disease had been repeatedly questioned. The recent and increased occurrence of relapsing fever in eastern and southern Sudan has been attributed to LBRF and not TBRF (Salih *et al.*, 1977).

As an endemic and sporadic disease, it seems unlikely that TBRF alone could have accounted for the 1974 outbreak which was epidemic and widespread in nature. The vectors involved in the 1976 outbreak, however, may be less certain. Argasid ticks were not reported during surveys of the villages in 1976, but TBRF was not believed to be involved at the time. Although the 1976 outbreak was less epidemic in nature than the one in 1974, it was reported from a number of different villages along the Gilo and Baro Rivers within a relatively short period. It is doubtful, therefore, that tick vectors alone could have been responsible.

It has been reported in the literature that louse-borne diseases such as relapsing fever are associated with conditions of a general abundance of lice among the people involved (Buxton, 1947; Felsenfeld, 1971; Busvine, 1975), and that scantily clad tribes in Africa are less liable to louse infestations (Kirk, 1939; Felsenfeld, 1971) and to louse-borne diseases (Mathis, 1931; Kirk, 1939; Buxton, 1947; Burgdorfer, 1976). In Ethiopia, LBRF has been primarily associated with the cold, highland areas (Bryceson *et al.*, 1970; Schaller, 1972). Contrary to these reports, relapsing fever was found to occur among nearly nude natives living at a low elevation and under climatic conditions considerably more tropical than those found in the highlands of Ethiopia. While the vector was not proven by field and laboratory investigations, epidemiological evidence suggests that the disease was primarily louse-borne; occurring under conditions of relative high louse prevalence but quite low levels per individual. Transmission was probably sustained, however, by native customs involving intimate contact and casual migration.

Since LBRF is prevalent throughout the highlands of Ethiopia, police, schoolteachers, administrative personnel and others who move in and out of the area from the highlands provide a constant and potential source of infection. The threat of future outbreaks of LBRF in the lowlands exists, therefore, not only from the Sudan but from Ethiopia itself.

LONGITUDINAL STUDY

A total of 2,359 persons were examined during the longitudinal study in Addis Ababa which began on 1 July 1974 and ended on 30 June 1976. Appendix Table 5 lists the median age, sex ratios, and the mean monthly frequency that clothes were washed and changed. Appendix Table 6 shows meteorological data including average diurnal temperature range, mean temperature, percent relative humidity, and precipitation.

Large diurnal temperature variations occurred throughout much of the 24 month period, particularly during the cold months of November and December. The lowest mean minimum temperature was 1.2°C (January, 1976) and the highest mean maximum temperature was 27.0°C (April, 1975); an amplitude of nearly 26°C (Fig. 13). Conversely, differences in mean monthly temperatures were small with a range of only 5°C between the coldest (November, 1974) and warmest (May, 1975) months. While annual ranges in temperature were less sharply contrasted in Addis Ababa, precipitation was clearly demarcated (Fig. 13). Overall, November and December were the coldest months with large fluctuations in diurnal temperatures and no precipitation. July through September were the wettest months with moderate temperatures and slight variations in diurnal temperatures. February through May were the warmest months with light precipitation and moderate changes in diurnal temperatures. These results are typical for the Ethiopian highlands where the seasons are determined more by differences in rainy and dry periods than by variations in mean monthly temperatures (Schaller, 1972).

As in the national survey, variations in louse prevalence and density could not be attributed to age, sex, ethnic or religious group differences recorded for each month (Table 7). It was apparent, however, that the frequency with which clothes were washed and changed had a major influence on pediculosis. As personal hygiene increased, the prevalence and density of head and body lice decreased significantly (Table 8).

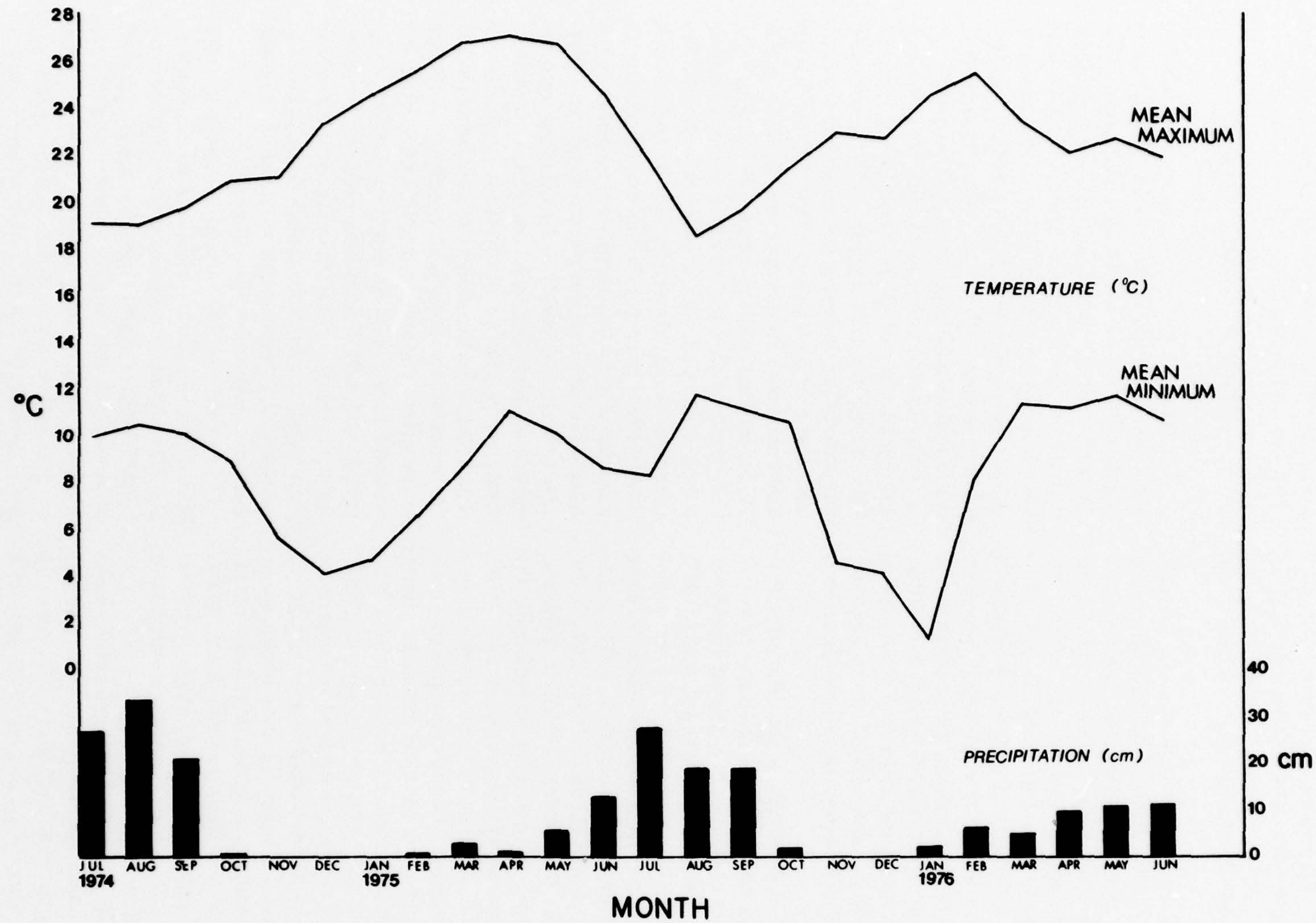

Figure 13. Mean monthly precipitation and diurnal temperatures for Addis Ababa, Ethiopia from July 1974 - June 1976.

Table 7. Percentage prevalence (%) and geometric mean (GM) levels of body and head lice found on 2359 persons during monthly surveys in Addis Ababa, Ethiopia.

Month	N	Body Lice				Head Lice			
		%	SE	GM	SD	%	SE	GM	SD
July 1974	47	42.6	7.2	2.7	5.4	12.8	4.9	0.1	1.4
August 1974	45	46.7	7.4	4.5	7.5	33.3	7.0	0.3	1.6
September 1974	105	61.0	4.8	5.7	5.7	11.4	3.1	0.1	1.5
October 1974	134	72.4	3.9	9.4	6.1	4.5	1.8	0.1	1.5
November 1974	66	68.2	5.7	9.6	6.5	9.1	3.5	0.1	1.7
December 1974	103	43.7	4.9	5.0	9.8	5.8	2.3	0.1	1.2
January 1975	103	40.8	4.8	4.0	8.0	12.6	3.3	0.2	1.9
February 1975	106	58.5	4.8	7.8	7.5	2.8	1.6	0.1	1.1
March 1975	101	58.4	4.9	7.7	8.0	3.0	1.7	0.1	1.3
April 1975	110	60.9	4.7	10.7	9.2	9.1	2.7	0.3	2.4
May 1975	100	63.0	4.8	7.1	6.2	13.0	3.4	0.5	3.5
June 1975	101	72.3	4.5	15.2	7.1	20.8	4.0	0.5	2.4
July 1975	102	66.7	4.7	11.4	7.5	17.6	3.8	0.6	3.1
August 1975	105	69.5	4.5	11.5	6.7	26.7	4.3	1.2	4.2
September 1975	105	76.2	4.2	45.3	11.6	51.4	4.9	4.3	5.6
October 1975	118	55.9	4.6	7.9	8.3	35.6	4.4	1.9	4.5
November 1975	102	49.0	5.0	5.8	8.0	26.5	4.4	1.2	4.2
December 1975	104	70.2	4.5	19.4	9.2	57.7	4.8	5.3	5.5
January 1976	99	72.7	4.5	26.9	9.9	48.5	5.0	4.4	6.5
February 1976	101	62.4	4.8	11.1	8.8	36.6	4.8	2.2	5.4
March 1976	101	71.3	4.5	25.3	11.2	54.5	5.0	5.5	7.0
April 1976	103	65.0	4.7	11.2	8.5	54.4	4.9	2.8	5.1
May 1976	100	61.0	4.9	13.9	12.4	45.0	5.0	4.1	6.9
June 1976	98	34.7	4.8	2.9	7.3	34.7	4.8	1.8	5.4
Total	2359	60.9	1.0	9.9	8.8	26.2	0.9	1.1	4.2

Table 8. Correlation coefficients of percentage prevalence (%) and geometric mean (GM) levels of human lice, and the frequency clothing was washed and changed during a 24 month period in Addis Ababa.

	Frequency Clothes Washed[a]			Frequency Clothes Changed[a]		
Louse Variable	N	r	P<	N	r	P<
% Body Lice	24	-.67	.001	14	-.86	.001
GM Body Lice	24	-.71	.001	14	-.82	.001
% Head Lice	24	-.41	.023	14	-.53	.026
GM Head Lice	24	-.54	.003	14	-.59	.014

[a]Based on mean annual rate per month

A correlation coefficient matrix was calculated for the variables studied (meteorological, pediculosis, personal hygiene, LBRF occurrence), and the results compared with graphs of the variables to determine which relationships should receive further attention. Figure 14 shows two of these variables, body louse prevalence and LBRF occurrence, which demonstrated some degree of correlation. In a scattergram for these two variables, the points for July-August 1974, and March-June 1976, were found to depart significantly from the main linear cluster of points. This departure was considered to be atypical for the following reasons: First, the longitudinal survey was primarily composed of subjects examined at the Municipal Clinic in sample sizes of about 100 per month. Only 92 individuals were examined during July-August 1974, and this was accomplished at locations other than the Municipal Clinic. Secondly, LBRF cases were recorded only from the Municipal Clinic and those for March-June 1976, were 3-5 times higher than for the same period of 1975. It was not possible, therefore, to obtain meaningful correlation coefficients between LBRF occurrence and any other variable studied. For these reasons, the atypical months were dropped from the data analysis and the correlation matrix re-calculated for an 18 month period.

For the 18 months, body louse prevalence showed a significant correlation between relative humidity ($r=0.47$, $P=0.024$) and precipitation ($r=0.40$, $P=0.005$). The association of increased body louse prevalence during the rainy period was the only evidence found that seasonal fluctuations occurred in the pediculosis variables.

Head louse prevalence and head and body louse density are clearly higher during the last 12 months of the study compared to the first 12 months (Table 7). The reasons for this increase are obscure. Although pediculosis and personal hygiene were closely associated, there was no significant change detected in the frequency with which clothes were washed and changed between the first and last 12 months of the study. Also, no significant correlations were found between the personal hygiene factors and any of the climatic variables.

There are conflicting reports in the literature concerning the possible occurrence of seasonal

fluctuations in louse infestations. In his assessment of the problem, Busvine (1969) has stated:

> It has frequently been alleged that lice show a seasonal variation in their incidence. There are, however, few figures available from which any safe conclusions can be drawn with regard to this suggestion. Such fluctuations as have been said to exist are more probably due to seasonal changes in the dress of the people rather than to the direct effects of seasonal changes on the insects themselves.

Among the low socioeconomic class in Ethiopia, the number of clothes worn are often considered a mark of pride and relative prosperity. There was little evidence that seasonal variations occurred in the amount or type of clothing worn by the study population in Addis Ababa. Most of the people examined appeared to own little more than a basic set of clothing which was worn throughout the year regardless of climatic changes.

The number of LBRF cases reported from the Municipal Clinic during the 18 month period showed a close association with relative humidity ($r=0.61$, $P=0.004$), precipitation ($r=0.64$, $P=0.002$), and temperature range ($r=-0.60$, $P=0.005$). The correlation between LBRF cases and mean monthly temperature was low and not significant by conventional standards ($r=0.39$, $P=0.053$).

Overall, LBRF occurrence fluctuated at a high level during the relatively wet months of March through September and was lowest during the dry months of October through February. This pattern coincided somewhat with the period when a greater number of persons were infested with body lice ($r=0.52$, $P=0.014$). There was no significant association found, however, between the density of body lice and LBRF occurrence.

The seasonal pattern of LBRF occurrence in Addis Ababa is not easily explained based on the evidence available from this study. The prevalence of body lice and the number of LBRF cases were correlated to some degree and both were correlated with precipitation, but there was no common factor or factors found which explained these associations. Since a relatively large proportion (61%) of the population was infested with body lice, it is possible that changes in the prevalence or the degree of infestations are of lesser importance to the seasonal occurrence of the disease than other undetermined factors.

In the Sudan, seasonal occurrence of LBRF was considered to be correlated with seasonal migrations of immigrant workers and not with meteorological differences (Kirk, 1939). The peak incidence of LBRF in Kaffa province, southwestern Ethiopia, has been associated with the coffee season; a period when seasonal coffee pickers migrated to the area. Immigrants into Addis Ababa who became daily laborers or remained unemployed were thought to provide a continuous supply of susceptibles into the city (Bryceson *et al.*, 1970).

In our study, there was no information available on the numbers or seasonal fluctuations of migrations into the city for association with the seasonal occurrence of the disease. Ethiopian holidays and festivals occurring during the 24 month period showed no obvious association with changes in louse populations or LBRF occurrence. This was true also of the increased political tension and economic disruption which occurred sporadically during the study.

For only those individuals who were louse infested, a correlation coefficient matrix was calculated for the meteorological variables, personal hygiene, LBRF occurrence and pediculosis. The analysis also was calculated to include only those persons who washed their clothes less than once a week. Finally, pediculosis and LBRF occurrence were compared with a one-month lag in the meteorological data to determine if there was a delayed effect of climatic conditions on louse populations or LBRF occurrence. In every instance, however, the coefficients obtained were smaller and less significant than those calculated previously for the 18- and 24-month periods.

PERSONAL AND SOCIOECONOMIC VARIABLES

Few studies have described the distribution of head and body lice in a human population as in-

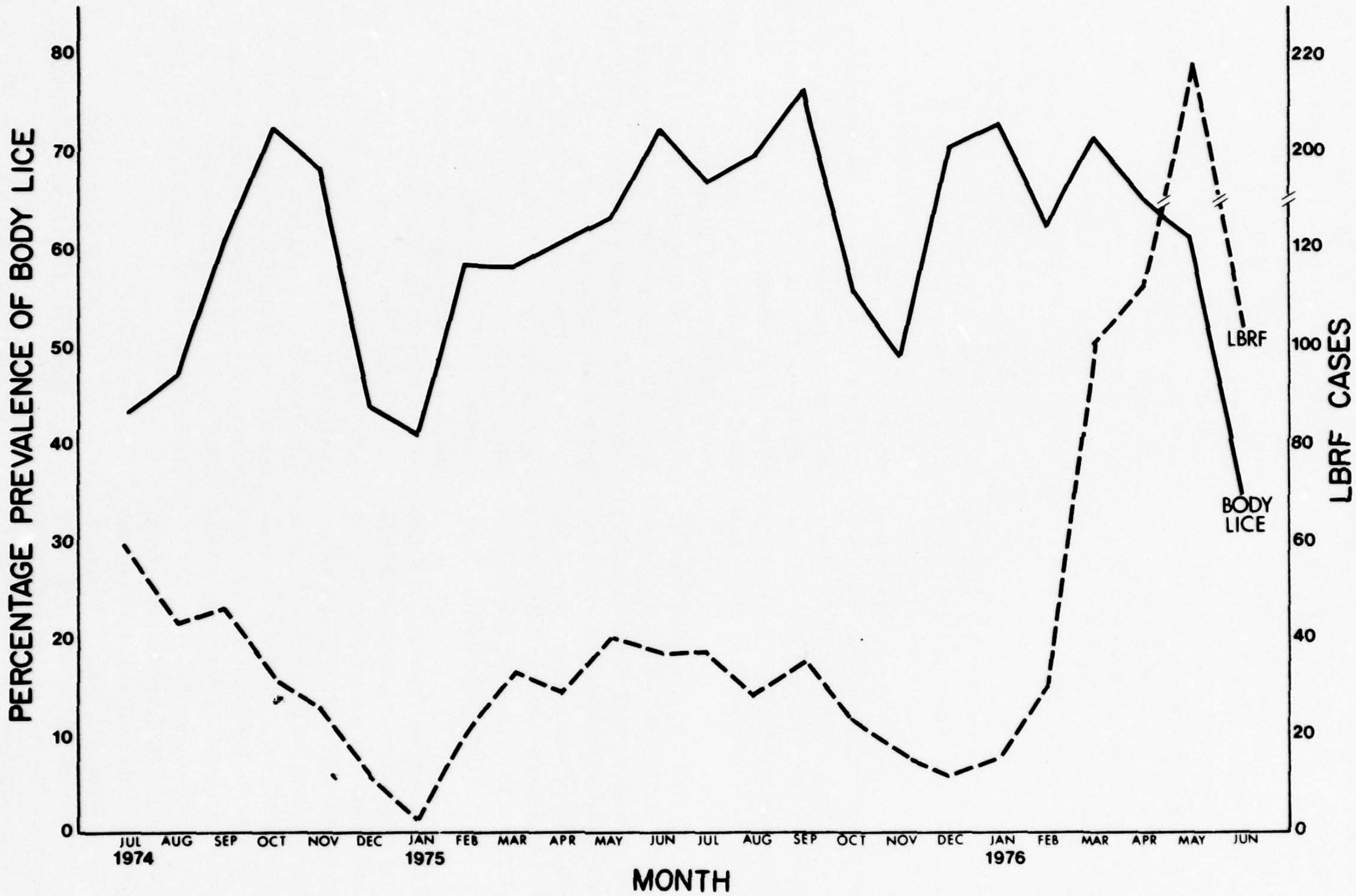

Figure 14. Percentage prevalence of body lice and the occurrence of louse-borne relapsing fever (LBRF) as recorded from the Municipal Clinic in Addis Ababa, Ethiopia from July 1974 - June 1976.

fluenced by a number of different personal and socioeconomic variables. The following observations are the most complete to date on the epidemiology of human pediculosis as affected by various host determinants.

The three field populations sampled are considered separately since they represent distinctly different social environments: Addis Ababa (urban), 49 towns and villages (rural) and 23 prisons (controlled). For convenience, these survey locations are referred to hereafter as the Addis Ababa, town or prison populations.

Variations in sample size occurred because some of the personal and socioeconomic variables were not included in the surveys until later in the investigation. Only age, sex and personal hygiene have been presented for the prison population since it showed little or no significant difference in pediculosis between subgroups of the variables considered.

The median age and sex ratios for the three populations were as follows:

Population	Median Age (Range)	Sex Ratio (M:F)
Addis Ababa	25.0 (2-85)	1.5
Towns	20.3 (<1-90)	1.9
Prisons	26.3 (10-99)	30.7

The proportion of people infested with body and head lice, and the degree of infestations encountered were significantly different between the three sample populations (Table 9). Body louse prevalence and density were highest in the prison population and lowest in the town population. Both prevalence and density of head lice, however, were highest in the Addis Ababa population and lowest in the prison population. Standard deviations for the geometric means shown were large, indicating that considerable variation occurred within the populations. This was also true for some of the personal and socioeconomic variables discussed below.

Prisons

The unique conditions found in the prisons visited are described because of their epidemiological importance in the occurrence of pediculosis and louse-borne diseases.

Most of the prisons visited were mud-walled and almost windowless structures which were dark, dirty and overcrowded. Usually the inmates slept huddled on a dirt floor on animal hides or on straw-stuffed mattresses which were often heavily infested with bed bugs and lice. At one facility, large collections of bed bug exuviae were found hanging from the mud walls while the overhead rafters were dark red from a large population of resting bed bugs; estimated at 1000-2000 bugs per square meter. At another prison, several of the inmates examined were hand-cuffed and secured in leg irons. Sanitation facilities were usually very limited and little opportunity existed for adequate personal hygiene such as clothes washing. Of the 698 prisoners examined, only 41% washed their clothing more often than once a month.

Such primitive conditions provide an optimum background for the transmission of louse-borne diseases. Yoseph (1962) discussed an epidemic of louse-borne typhus in the prison at Gondar noting that the prisoners and their bedding were heavily infested with lice. Epidemiological surveys by NAMRU-5 some 15 years later indicated that conditions in the Gondar prison had changed very little. Outbreaks of typhus occurred sporadically and most of the inmates were heavily infested with body lice.

The heads of inmates were shaved upon their arrival at a prison and at intervals thereafter which explains the lowered occurrence of head lice.

Age

Overall, the proportion of persons with body lice increased gradually with age (Table 10). For the Addis Ababa population, the chi-square test for linearity (X^2_l) was significant while that for departure from linearity (X^2_d) was not significant indicating that a strong linear relationship existed between body louse prevalence and age. A significant linear relationship was not found, however, for the prison population; the opportunities for becoming infested with body lice apparently

Table 9. Percentage prevalence (%) and geometric mean (GM) levels of body and head lice for 5492 persons in Addis Ababa, 49 towns and 23 prisons.

Population	No. Persons	Body Lice %	Body Lice SE	Body Lice GM	Body Lice SD	Head Lice %	Head Lice SE	Head Lice GM	Head Lice SD
Addis Ababa	2359	60.9	1.0	9.9a*	8.8	26.2	0.9	1.1a	4.2
Towns	2435	59.1	1.0	5.0b	6.1	24.4	0.9	0.6b	2.7
Prisons	698	75.5	1.6	12.2c	6.8	11.0	1.2	0.2c	2.0
		$X^2 = 63.87(2)P<0.001$**				$X^2 = 71.05(2)P<0.001$			

*Means followed by different letters are significantly different at the 5% level (Duncan's multiple range test).

**Chi-square test for equality of percentage prevalence for the Addis Ababa, town and prison populations.

Table 10. Percentage prevalence (%) and geometric mean (GM) levels of body and head lice for different age groups in Addis Ababa, 49 towns and 23 prisons.

			Body Lice				Head Lice			
Population	Age Group	N	%	SE	GM	SD	%	SE	GM	SD
Addis Ababa	< 1-9	88	53.4	5.3	5.8a*	6.8	29.5	4.9	1.2a	4.0
	10-19	590	56.6	2.0	7.8a	8.4	31.4	1.9	1.4a	4.5
	20-29	782	61.0	1.7	10.2a	8.9	26.1	1.6	1.2a	4.2
	30-39	431	62.4	2.3	9.9a	8.6	23.9	2.1	1.0a	3.9
	40-49	268	64.2	2.9	12.8a	9.2	21.6	2.5	0.9a	3.8
	50-59	114	63.2	4.5	10.9a	9.1	20.2	3.8	0.8a	3.8
	60-69	79	77.2	4.7	23.8b	8.9	22.8	4.7	0.9a	4.0
	70-79+	7	71.4	17.1	15.7ab	7.7	14.3	13.2	0.1a	1.3
	Total	2359	60.9	1.0	9.9	8.8	26.2	0.9	1.1	4.2
			$X^2_T = 17.36(6) P=0.008$**				$X^2_T = 15.44(6) P=0.017$			
			$X^2_r = 14.19(1) P<0.001$				$X^2_r = 12.32(1) P<0.001$			
			$X^2_d = 3.17(5)$NS				$X^2_d = 3.12(5)$NS			
Towns	< 1-9	392	36.5	2.4	1.3a	3.7	21.7	2.1	0.3a	2.0
	10-19	712	62.9	1.8	5.0b	5.5	32.4	1.8	0.7a	2.7
	20-29	570	63.3	2.0	6.5b	6.4	23.0	1.8	0.7a	3.1
	30-39	354	61.9	2.6	6.6b	6.6	19.5	2.1	0.5a	2.6
	40-49	213	63.8	3.3	7.9b	7.1	22.1	2.8	0.6a	2.8
	50-59	81	67.9	5.2	6.4b	6.1	9.9	3.3	0.2a	1.9
	60-69	95	68.4	4.8	9.3b	7.6	23.2	4.3	0.8a	3.5
	70-79+	18	66.7	11.1	10.2b	7.7	5.6	5.4	0.1a	1.2
	Total	2435	59.1	1.0	5.0	6.1	24.4	0.9	0.6	2.7
			$X^2_T = 100.75(7) P<0.001$				$X^2_T = 44.84(7) P<0.001$			
			$X^2_r = 39.70(1) P<0.001$				$X^2_r = 12.55(1) P<0.001$			
			$X^2_d = 61.05(6) P<0.001$				$X^2_d = 32.29(6) P<0.001$			

Table 10. Continued.

Population	Age Group	N	Body Lice %	Body Lice SE	Body Lice GM	Body Lice SD	Head Lice %	Head Lice SE	Head Lice GM	Head Lice SD
Prisons	< 1-9	0	-	-	-	-	-	-	-	-
	10-19	104	74.0	4.3	11.2a	6.1	20.2	3.9	0.4a	2.3
	20-29	311	76.5	2.4	12.6a	6.7	9.6	1.7	0.2a	2.0
	30-39	138	71.7	3.8	12.2a	8.0	11.6	2.7	0.3a	2.4
	40-49	64	76.6	5.3	9.0a	6.5	6.3	3.0	0.1a	1.4
	50-59	37	73.0	7.3	17.8a	8.4	10.8	5.1	0.2a	1.9
	60-69	25	80.0	8.0	10.2a	5.4	4.0	3.9	0.1a	1.2
	70-79+	19	89.5	7.0	20.8a	4.3	5.3	5.1	0.1a	1.2
	Total	698	75.5	1.6	12.2	6.8	11.0	1.2	0.2	2.0
			X_T^2 = 3.82(6)NS				X_T^2 = 12.97(6)P=0.044			
							X_r^2 = 5.53(1)P=0.019			
							X_d^2 = 7.44(5)NS			

*Means followed by different letters are significantly different at the 5% level (Duncan's multiple range test).

**Chi-square tests for equality of percentage prevalence for all age groups: X_T^2 = standard chi-square; X_r^2 = test for linearity; X_d^2 = test for departure from linearity. Sample sizes less than 10 not included in the analysis.

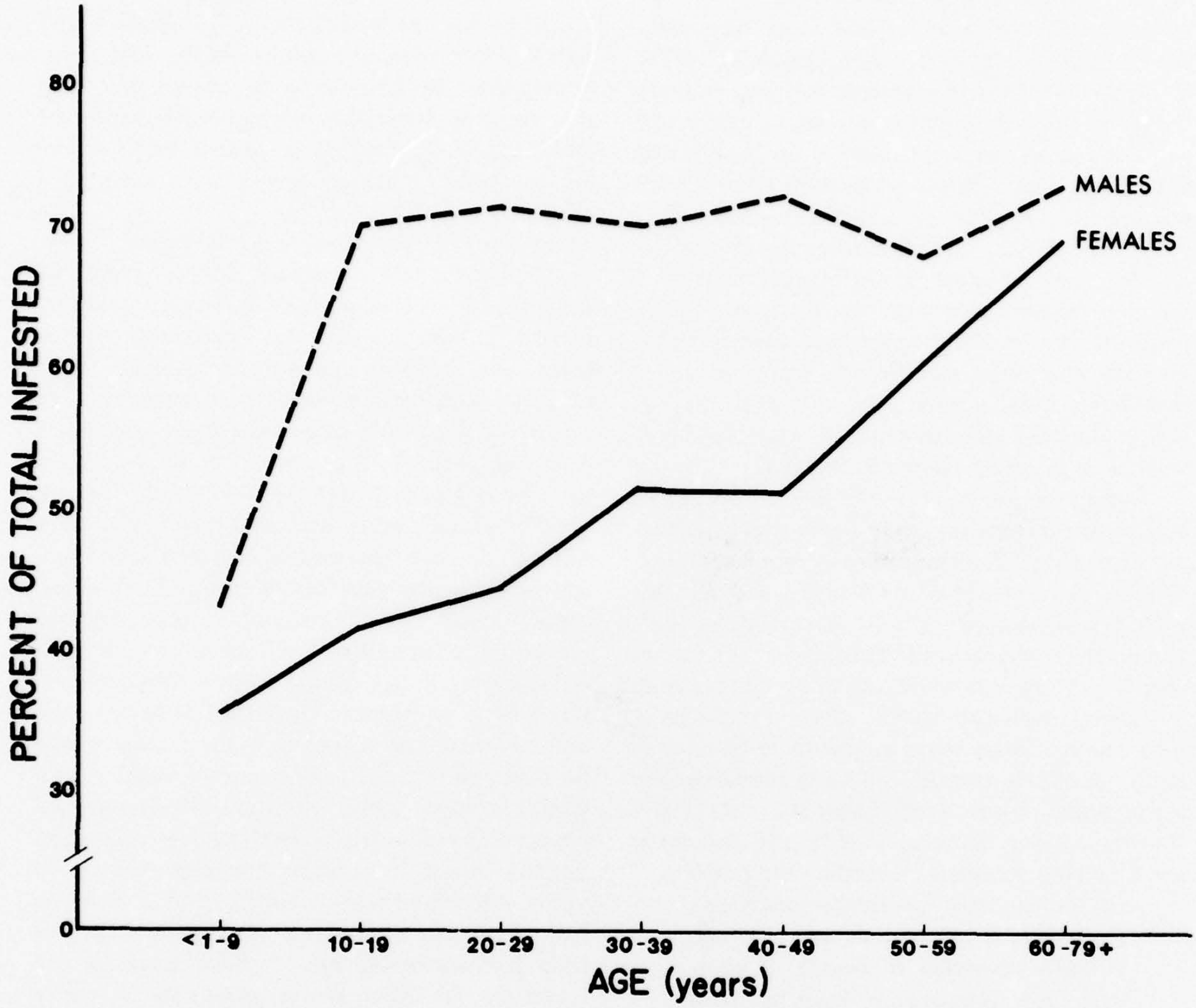

Figure 15. Body louse prevalence by age group for 1,777 females and 3,017 males from the Addis Ababa and town populations.

being equal for all age groups. The trend of the geometric means suggests that body louse density also increased with age. This increase was not significant, however, for any of the three sample populations.

Figure 15 shows the percentage prevalence of body lice by age group for 1,777 females and 3,017 males from the Addis Ababa and town populations. Age group "70-79+" was combined with age group "60-69" because of the small sample size of the former. Of interest is the gradual increase in the proportion of females infested with body lice while the males show a dramatic increase after age 9 and remain high throughout.

Infants and young children in Ethiopia wear comparatively fewer clothes than adults, and the reduced attack rate and density of body lice below

age ten was anticipated. The clothing for this age group (<1-9) was also washed more frequently than for the other age groups (Appendix Table 7).

The reasons for the increase with age in body louse infestations remain unclear. Persons 50 years old and older were more often found to be uneducated and a larger proportion (58%) were unemployed, beggars or common laborers. Personal hygiene may have deteriorated with age but this was not indicated by differences in clothes washing frequency between the age groups (Appendix Table 7). The frequency of clothes washing, however, was significantly lower in males than females (Appendix Table 7). This may in part explain the early increase in body louse prevalence in males compared to females.

During the period of 1874-1887, 337 cases of body louse infestations were diagnosed at a Boston dispensary. Percentage prevalence was found to increase with age in both males and females with the highest rate (23%) occurring in individuals over 60 years old. This high attack rate in elderly persons was attributed to poorer personal hygiene (Greenough, 1887). Other investigators have reported body louse incidence to be notably higher in elderly persons but no quantitative data are provided (Knott, 1905; Garnham *et al.*, 1947; Busvine, 1966). Busvine (1969) has also made the following comments regarding the problem:

> Under modern civilized conditions Body Louse infestations are rare and virtually restricted to people of obviously low standards of hygiene, such as vagrants, who rarely change their underwear and commonly sleep in their clothes.

The proportion of individuals infested with head lice was also related linearly to age, but, in this case, it declined rather than increased with age (Table 10). For the Addis Ababa and prison populations, the decrease in head louse prevalence with age showed a strong linear relationship; the value for X_r^2 being significant while that for X_d^2 was not significant. Although not significant by conventional standards, the trend for the geometric means for the Addis Ababa and prison populations suggests that head louse levels also decreased with age.

Figure 16 shows the percentage prevalence of head lice by age group for 1,777 females and 3,017 males from the Addis Ababa and town populations. In contrast to the results for body lice, the proportion of males and females infested with head lice was closely correlated for the different age groups; the prevalence rates reaching a peak in the 10-19 age group.

Our results for head louse prevalence confirms observations elsewhere. In his studies of head lice in hair crops from different countries, Buxton (1938) reported that head louse prevalence decreased with age in males. Jalayer (1967) observed a decline in head louse occurrence in males and females in Iran; the highest prevalence occurring in the 7-12 age group. Similar declines have been reported by Lang (1975) and Juranek (1977). These studies and others reviewed were limited, however, because of the relatively small age range of the populations sampled. Two exceptions were found: Greenough (1887) reported the results of head louse prevalence in 500 subjects ranging in age from 1 to over 60 years old. Head louse prevalence decreased with age; the highest attack rate occurring in the 1-5 age group for males and the 5-10 age group for females. In a more extensive study, Mellanby (1941) reported observations on nearly 60,000 persons in England ranging in age from under one year to over 70 years. Infestation rates declined steadily in males from about age three while in females there was little decrease before age 13. Mean levels of lice found for the different age groups in the above studies were not reported.

Buxton (1938) summarized arithmetic and logarithmic means of head lice by age group for males from four locations in Africa and Asia. In Kakamego, Kenya, 177 hair crops were examined from persons ranging in age from under one year to 31 years and over. The prevalence and density of head lice reached a peak in the 11-15 age group and steadily decreased thereafter.

The higher prevalence of head lice on children than on older adults was noted by Aristotle (Busvine, 1976), yet the reasons for this phenomenon have never been fully explained. Various researchers have suggested that the decline in head louse prevalence with age may be due to alopecia in males (Greenough, 1887), differences in per-

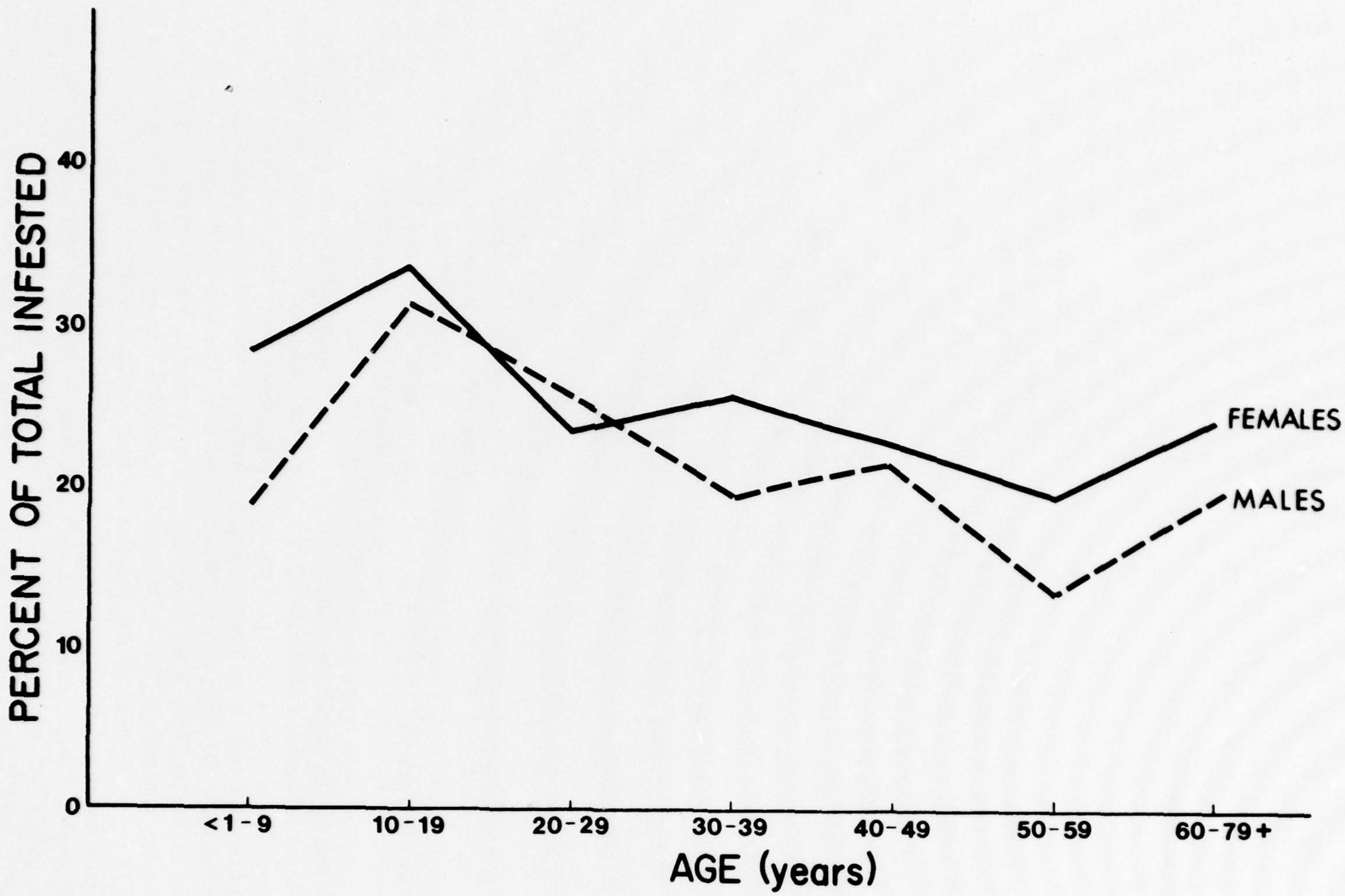

Figure 16. Head louse prevalence for 1,777 females and 3,017 males from the Addis Ababa and town populations.

sonal grooming habits (Buxton, 1938; Lang, 1975), and the sharing of toilet articles and differences in interpersonal contact (Slonka, 1975). Whatever the reasons may be, it is of interest that the factors which are responsible for the increased prevalence of body lice with age apparently do not have the same effect on head lice.

Sex

Males had significantly higher infestation rates and levels of body lice than females for all three sample populations (Table 11). Our results agree with those found in the literature. Greenough (1887) found that of 337 persons infested with body lice in Boston, 58% were males while 42% were females. In India, Hati *et al.* (1974) examined 277 persons and reported that 13% of the males and 6% of the females were infested with body lice. The density of lice was not reported.

Males examined in our study generally lived under conditions more conducive to the acquisition and maintenance of body louse populations than did females. A smaller percentage of females (32%) were beggars, unskilled laborers or unemployed, compared to males (54%), and a greater number of females were married (47%) compared to the males (24%); marriage usually meaning a more stable existence. Finally, females washed their clothes significantly more often than did males (Appendix Table 7).

The proportion of individuals with head lice was higher for females than males but this difference was not statistically significant. There was also no significant difference found between sex and the density of head lice (Table 11). Our results for head lice differ from those frequently reported in the literature. Of 500 persons infested with head lice in Boston, 16% were males and 84% were females (Greenough, 1887). In Iran, Jalayer (1967) reported 78% of the females examined to be infested with head lice compared to 16% of the males. Similar observations have been made in India (Hati *et al.*, 1974), England (Mellanby, 1941; Donaldson, 1976) and Arizona (Lang, 1975).

In Buffalo, New York, Slonka *et al.* (1977) found no significant difference between attack rates in boys and girls at one elementary school while in a city-wide survey, head louse prevalence was significantly greater in the girls. Buxton (1938) concluded that,

> . . . in many countries girls and women tend to be more frequently infested with head-lice than in others, but that in other countries this is not so: the difference between countries doubtless depends upon local customs in hair-cutting and coiffure.

A variety of hair styles are worn by the different ethnic groups in Ethiopia, particularly by women. These different styles, hair-cutting practices and the use of hair dressings were noted during the present study. This included the practice of applying dabs of butter to the hair; a custom observed in Ethiopian women over 125 years ago (Parkyns, 1966). As shown in Figure 17, the hair may be plaited in complicated rows of short and long tresses and then treated with quantities of rancid butter. The application of butter to the hair was reportedly done for cosmetic reasons or as a therapeutic measure for headaches or fever. Some individuals examined also stated that they applied butter to their hair to control head lice. Castor oil is applied to the hair and body by the Anuaks and colored clay is incorporated into the hair styles of other tribes including the Mesengo and Guleb (Fig. 18). Males of the poorer socio-economic group often shave their heads; a practice performed by both sexes after the death of a relative or close friend.

The influence the above practices may have had on head louse populations was difficult to assess. Head lice were not found on Mesengo women whose hair was completely covered with red clay. This was not the case, however, for the Guleb males who carved a special wooden "scratcher" to reach head lice breeding beneath their elaborate coiffures of hair and clay (Fig. 18). Head lice were absent on a number of individuals with rancid butter in their hair, but this was not always true. For example, 237 head lice were recovered from one young girl in the hospital study whose plaited hair was heavily coated

Table 11. Percentage prevalence (%) and geometric mean (GM) levels of body and head lice for males and females in Addis Ababa, 49 towns and 23 prisons.

Population	Sex	N	Body Lice %	Body Lice SE	Body Lice GM	Body Lice SD	Head Lice %	Head Lice SE	Head Lice GM	Head Lice SD
Addis Ababa	Female	948	45.0	1.6	3.7a*	6.4	28.0	1.5	1.1a	3.8
	Male	1411	71.6	1.2	18.1b	9.0	25.0	1.2	1.1a	4.4
	Total	2359	60.9	1.0	9.9	8.8	26.2	0.9	1.1	4.2
			X^2 = 169.00(1)P<0.001**				X^2 = 2.53(1)NS			
Towns	Female	829	47.2	1.7	2.7a	5.1	25.3	1.5	0.6a	2.6
	Male	1606	65.3	1.2	6.7b	6.3	23.9	1.1	0.6a	2.8
	Total	2435	59.1	1.0	5.0	6.1	24.4	0.9	0.6	2.7
			X^2 = 74.54(1)P<0.001				X^2 = 0.60(1)NS			
Prisons	Female	22	31.8	9.9	1.0a	3.4	18.2	8.2	0.3a	2.1
	Male	676	76.9	1.6	13.1b	6.7	10.8	1.2	0.2a	2.0
	Total	698	75.5	1.6	12.2	6.8	11.0	1.2	0.2	2.0
			X^2 = 23.44(1)P<0.001				X^2 = 1.18(1)NS			

*Means followed by different letters are significantly different at the 5% level (Duncan's multiple range test).

***Chi-square test for equality of percentage prevalence for males and females.*

Figure 17. Galla girl whose plaited hair has been liberally treated with rancid butter.

with butter. Although individuals with short hair were usually less infested with lice than those with long hair, 106 head lice were recovered from one male patient whose overall hair length was 2.2 cm. A total of 375 head lice were found on another male patient whose hair averaged 3.0 cm in length.

Ethnic Group

A total of 25 different ethnic groups was sampled for head and body lice in the Addis Ababa and town populations. The heterogeneity of Ethiopia's ethnic composition makes classifying the various tribes and races a difficult task. The classification scheme used here follows that proposed by Levine (1974) except for two groups which we have added: The Wolkaits, a group from the Wolkait district of Begemder province near Humera, and the Shankalla (an Amharic term used collectively for the Negroid tribes of Ethiopia), a group found near Didessa in Wollega province. Specific or generally accepted ethnic group names for these two tribes could not be found in Levine or other sources. Further information on the ethnic groups of Ethiopia can be found in Schaller (1972), Ullendorff (1973) and Bender *et al.* (1976).

Although certain groups showed distinct differences in their louse infestations (Table 12), there was not sufficient evidence available to associate these differences with variations in tribal attitudes and customs regarding hair dressing, washing or other personal grooming and hygiene practices.

Religion

A majority of the individuals examined for lice in the field surveys were either Coptic Chris-

Figure 18. Guleb man with an elaborate coiffure of colored clay and hair. As the hair grows out, head lice may be found breeding next to the scalp.

Table 12. Percentage prevalence (%) and geometric mean (GM) levels of body and head lice for different ethnic groups in Addis Ababa and 49 towns.

Population	Ethnic Group	N	Body Lice %	Body Lice SE	Body Lice GM	Body Lice SD	Head Lice %	Head Lice SE	Head Lice GM	Head Lice SD
Addis Ababa	Afar	0	-	-	-	-	-	-	-	-
	Amhara	1386	56.5	1.3	7.5a*	8.3	25.5	1.2	1.0abc	3.9
	Anuak	0	-	-	-	-	-	-	-	-
	Arab	0	-	-	-	-	-	-	-	-
	Arussi	1	100.0	0.0	19.9	0.0	100.0	0.0	5.0	0.0
	Berta	0	-	-	-	-	-	-	-	-
	Dorze	17	76.5	10.3	31.7ab	11.3	29.4	11.0	1.2abc	4.7
	Galla	457	65.0	2.2	13.4a	9.3	27.8	2.1	1.3abc	4.6
	Gemu	5	80.0	17.9	181.4b	20.5	60.0	21.9	10.0c	10.1
	Gimira	0	-	-	-	-	-	-	-	-
	Gofa	1	100.0	0.0	99.9	0.0	100.0	0.0	14.9	0.0
	Guji	0	-	-	-	-	-	-	-	-
	Gurage	296	75.3	2.5	20.4ab	7.9	30.7	2.7	1.5bc	4.7
	Kaffa	2	50.0	35.4	21.4	81.1	0.0	0.0	0.0	0.0
	Kambata	36	75.0	7.2	19.4ab	8.1	19.4	6.6	0.7ab	3.3
	Konso	0	-	-	-	-	-	-	-	-
	Konta	0	-	-	-	-	-	-	-	-
	Kullo	4	100.0	0.0	108.5	9.4	0.0	0.0	0.0	0.0
	Nuer	0	-	-	-	-	-	-	-	-
	Shankalla	1	100.0	0.0	11.9	0.0	0.0	0.0	0.0	0.0
	Sidamo	5	100.0	0.0	39.1ab	7.0	20.0	17.9	0.8abc	3.9
	Somali	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Tigre	104	41.3	4.8	3.9a	8.3	17.3	3.7	0.7a	3.6
	Wolamo	42	81.0	6.1	20.6ab	5.7	23.8	6.6	0.9abc	3.9
	Wolkait	0	-	-	-	-	-	-	-	-
	Total	2359	60.9	1.0	9.9	8.8	26.2	0.9	1.1	4.2
			$X^2 = 69.24(6) P<0.001^{**}$				$X^2 = 9.33(6)$NS			

Table 12. Continued.

Population	Ethnic Group	N	Body Lice				Head Lice			
			%	SE	GM	SD	%	SE	GM	SD
Towns	Afar	25	12.0	6.5	0.4a	2.7	12.0	6.5	0.6ab	3.6
	Amhara	653	57.0	1.9	4.4ab	5.8	20.0	1.6	0.5ab	2.6
	Anuak	153	49.0	4.0	1.2a	2.8	62.7	3.9	1.5b	2.6
	Arab	4	0.0	0.0	0.0	0.0	25.0	21.6	0.4	2.0
	Arussi	28	17.9	7.2	0.6a	2.9	14.3	6.6	0.2ab	1.5
	Berta	62	37.1	6.1	1.3a	3.4	24.2	5.4	0.3ab	1.9
	Dorze	0	-	-	-	-	-	-	-	-
	Galla	729	65.4	1.8	8.1b	6.6	27.0	1.6	0.8ab	3.1
	Gemu	25	96.0	3.9	13.3b	2.5	0.0	0.0	0.0a	0.0
	Gimira	31	38.7	8.8	3.7ab	8.5	0.0	0.0	0.0a	0.0
	Gofa	12	58.3	14.2	2.8ab	3.4	8.3	8.0	0.1ab	1.5
	Guji	28	89.3	5.8	12.2b	3.3	28.6	8.5	1.3b	4.4
	Gurage	44	47.7	7.5	3.9ab	6.1	22.7	6.3	0.8ab	3.7
	Kaffa	62	87.1	4.3	12.9b	3.5	1.6	1.6	0.1ab	1.3
	Kambata	5	60.0	21.9	6.9ab	7.2	0.0	0.0	0.0ab	0.0
	Konso	3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Konta	26	65.4	9.3	3.7ab	4.5	26.9	8.7	0.2ab	1.4
	Kullo	69	52.2	6.0	6.9ab	10.0	17.4	4.6	0.6ab	3.3
	Nuer	50	74.0	6.2	1.4a	2.2	24.0	6.0	0.3ab	1.7
	Shankalla	67	49.3	6.1	4.5ab	6.1	20.9	5.0	0.7ab	2.9
	Sidamo	31	67.7	8.4	7.7b	7.6	51.6	9.0	0.9ab	2.8
	Somali	64	51.6	6.2	3.8ab	6.2	26.6	5.5	0.9b	3.3
	Tigre	236	60.6	3.2	5.7ab	7.1	19.9	2.6	0.2ab	1.8
	Wolamo	25	68.0	9.3	6.8ab	7.3	12.0	6.5	0.6ab	3.8
	Wolkait	3	33.3	27.2	1.2	4.0	0.0	0.0	0.0	0.0
	Total	2435	59.1	1.0	5.0	6.1	24.4	0.9	0.6	2.7
			X^2 = 159.95(19)P<0.001				X^2 = 193.87(19)P<0.001			

*Means followed by different letters are significantly different at the 5% level (Duncan's multiple range test). Sample sizes less than 5 not included in the analysis.

**Chi-square test for equality of percentage prevalence for all ethnic groups; sample sizes less than 10 not included in the analysis.

tians or Muslims, and it was anticipated that the religious practice of ablution by the latter might result in their having relatively lower body louse infestations. This may have been the case for the town populations where Muslims had lower rates and levels of body lice than the Coptic Christians. The reverse was true, however, in the Addis Ababa population (Table 13).

The reasons for these differences remain unclear and it is likely that where water is scarce the average Muslim is able to perform only ceremonial ablutions. During his travels in Ethiopia,

Table 13. Percentage prevalence (%) and geometric mean (GM) levels of body and head lice for different religious groups in Addis Ababa and 49 towns.

Population	Religious Group	N	Body Lice %	Body Lice SE	Body Lice GM	Body Lice SD	Head Lice %	Head Lice SE	Head Lice GM	Head Lice SD
Addis Ababa	Coptic	1309	62.4	1.3	11.9a*	9.4	37.4	1.3	2.2a	5.3
	Muslim	129	75.2	3.8	22.4b	8.0	38.0	4.3	1.9a	4.8
	Tribal	0	-	-	-	-	-	-	-	-
	Protestant	1	100.0	0.0	19.9	0.0	0.0	0.0	0.0	0.0
	Total	1439	63.6	1.3	12.6	9.3	37.4	1.3	2.2	5.3
			$X^2 = 8.28(1)P<0.004$**				$X^2 = 0.02(1)NS$			
Towns	Coptic	1707	62.5	1.2	6.3a	6.3	19.9	1.0	0.5a	2.6
	Muslim	396	49.7	2.5	3.7b	6.2	26.8	2.2	0.7b	3.0
	Tribal	228	55.3	3.3	1.6c	3.1	46.7	3.3	1.1b	2.7
	Protestant	24	37.5	9.9	0.5c	1.8	45.8	10.2	0.6ab	1.9
	Total	2355	59.4	1.0	5.0	6.1	23.9	0.9	0.6	2.7
			$X^2 = 28.53(3)P<0.001$				$X^2 = 86.98(3)P<0.001$			

*Means followed by different letters are significantly different at the 5% level (Duncan's multiple range test). Sample sizes less than 5 not included in the analysis.

**Chi-square test for equality of percentage prevalence for all religious groups; sample sizes less than 10 not included in the analysis.

Hayes (1905) remarked: "But, in spite of their ablutions, they (Muslims) are infested like the rest of the inhabitants, with body lice." Muslims washed their clothes less frequently than Coptic Christians in Addis Ababa but the reverse was true for the town populations (Appendix Table 7). Personal hygiene appears to have, therefore, more influence on pediculosis than religious beliefs.

Education Level

The high illiteracy rate in Ethiopia was reflected in this present study where 79% of the individuals examined stated they had never received any formal education and only 10% had completed the fourth grade.

Table 14 shows the percentage prevalence and geometric mean levels of head and body lice by education level for the Addis Ababa and town populations. Categories of education levels used in the table were 1-4 and 5-8 for elementary school, 9-12 for secondary school and 13-16 for higher education. Overall, both the prevalence and density of head and body lice were found to decrease with increased literacy.

Clothes washing rates increased with education level but the differences were not found to be significant in all instances (Appendix Table 7).

Marital Status

Marital status seemed to have little influence on pediculosis. Exceptions were married persons who had significantly lower head and body louse infestations in Addis Ababa and lower head louse infestations in the town population. Divorced persons in the town population also had significantly higher levels of head and body lice (Table 15). There was little significant difference in marital status and the frequency that clothes were washed (Appendix Table 7).

Occupation

A total of 19 different occupations were determined for the Addis Ababa and town populations. As shown in Table 16, differences in louse infestations between the occupational subgroups were usually more significant for body lice than for head lice. Variations also occurred between the Addis Ababa and town populations for the same subgroup. In general, the high risk groups for pediculosis included beggars, farmers, laborers, priests and unemployed persons. Low risk groups for pediculosis included clerks, teachers, dressers, truck drivers, police and military personnel.

The high risk groups generally washed their clothes less frequently than the low risk groups but the differences were not always significant. A notable exception was beggars who on the average washed their clothing less than twice a year.

Length of Residence

Pediculosis was compared between settled persons and recent migrants (those persons having lived in an area for less than six months). Migrants had significantly higher attack rates and levels of body lice compared to settled persons, but there was no difference between the two groups in head louse infestations (Table 17).

The migrants examined in the study were mostly seasonal laborers, beggars and unemployed persons living under crowded and insanitary conditions. The latter was especially evident in Addis Ababa where the frequency with which clothes were washed by the settled persons was nearly twice that of the migrants (Appendix Table 7).

Urban-Rural Residence

The Addis Ababa and town populations were grouped according to their residence in rural or urban environments to determine if differences in pediculosis occurred between the two. Since Ethiopia is a predominantly rural country, the grouping of people by urban or rural residence presents some difficulties. This was not a problem for the Addis Ababa population which was mostly and obviously urban. For the town populations, individials residing in the town proper were

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Table 14. Percentage prevalence (%) and geometric mean (GM) levels of body and head lice for different educational levels in Addis Ababa and 49 towns.

Population	Education Level	N	Body Lice %	Body Lice SE	Body Lice GM	Body Lice SD	Head Lice %	Head Lice SE	Head Lice GM	Head Lice SD
Addis Ababa	None	1113	69.9	1.4	17.0a*	8.9	39.4	1.5	2.4a	5.4
	1-4	137	49.6	4.3	5.1b	7.8	35.8	4.1	1.9ab	5.1
	5-8	146	40.4	4.1	4.6b	9.7	30.8	3.8	1.4b	4.6
	9-12	43	23.3	6.5	1.5c	6.2	11.6	4.9	0.4c	2.4
	13-16	0	-	-	-	-	-	-	-	-
	Total	1439	63.6	1.3	12.6	9.3	37.4	1.3	2.2	5.3
			X^2_T = 94.77(3)P<0.001**				X^2_T = 17.00(3)P<0.001			
			X^2_r = 90.49(1)P<0.001				X^2_r = 14.95(1)P<0.001			
			X^2_d = 4.28(2)NS				X^2_d = 2.05(2)NS			
Towns	None	793	64.8	1.7	6.7a	6.0	33.4	1.7	1.2ab	3.5
	1-4	106	32.1	4.5	1.4bc	4.1	35.8	4.7	0.8ab	2.8
	5-8	60	36.7	6.2	2.8b	6.2	33.3	6.1	1.6a	4.1
	9-12	27	14.8	6.8	0.6c	3.9	11.1	6.0	0.3b	2.7
	13-16	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Total	987	58.2	1.6	5.2	6.0	33.0	1.5	1.1	3.5
			X^2_T = 76.19(3)P<0.001				X^2_T = 6.29(3)NS			
			X^2_r = 59.34(1)P<0.001							
			X^2_d = 16.85(2)P<0.001							

*Means followed by different letters are significantly different at the 5% level (Duncan's multiple range test); sample sizes less than 5 not included in the analysis.

**Chi-square tests for equality of percentage prevalence for all education levels: X^2_T = standard chi-square; X^2_r = test for linearity; X^2_d = test for departure from linearity. Samples sizes less than 10 not included in the analysis.

considered to be urban while those living in the countryside were classified as rural. For small villages, all of the individuals examined were classified as rural.

Residents in rural areas showed higher prevalence and levels of head and body lice compared to persons residing in urban areas; a difference which was highly significant in all instances ex-

Table 15. Percentage prevalence (%) and geometric mean (GM) levels of body and head lice by marital status for Addis Ababa and 49 towns.

Population	Marital Status	N	Body Lice %	Body Lice SE	Body Lice GM	Body Lice SD	Head Lice %	Head Lice SE	Head Lice GM	Head Lice SD
Addis Ababa	Divorced	182	63.2	3.6	11.7a*	9.2	37.9	3.6	2.0a	5.0
	Married	563	49.2	2.1	4.9b	7.1	22.9	1.8	0.8b	3.4
	Single	871	64.9	1.6	14.3a	10.0	39.0	1.7	2.4a	5.6
	Widow(er)	68	67.6	5.7	13.7a	8.0	35.3	5.8	2.0a	4.9
	Total	1684	59.6	1.2	9.9	9.1	33.4	1.2	1.7	4.9
			$X^2 = 38.11(3)P<0.001$**				$X^2 = 42.06(3)P<0.001$			
Towns	Divorced	33	60.6	8.5	14.8a	13.0	45.5	8.7	3.4a	5.7
	Married	610	60.2	2.0	5.3b	5.6	24.3	1.7	0.7b	2.9
	Single	1001	52.1	1.6	3.5c	5.5	31.7	1.5	0.8b	2.9
	Widow(er)	32	56.3	8.8	4.9bc	6.3	34.4	8.4	1.4b	4.7
	Total	1676	55.3	1.2	4.2	5.8	29.3	1.1	0.8	3.0
			$X^2 = 10.25(3)P=0.017$				$X^2 = 14.95(3)P=0.002$			

*Means followed by different letters are significantly different at the 5% level (Duncan's multiple range test).

**Chi-square test for equality of percentage prevalence for all marital status groups.

Table 16. Percentage prevalence (%) and geometric mean (GM) levels of body and head lice by occupation for Addis Ababa and 49 towns.

Population	Occupation	N	Body Lice				Head Lice			
			%	SE	GM	SD	%	SE	GM	SD
Addis Ababa	Beggar	49	98.0	2.0	213.1e*	4.9	38.8	7.0	3.6b	7.9
	Clerk	6	0.0	0.0	0.0a	0.0	0.0	0.0	0.0a	0.0
	Craftsman	46	54.3	7.3	6.5bc	8.0	19.6	5.9	0.6ab	2.8
	Dresser	0	-	-	-	-	-	-	-	-
	Farmer	85	83.5	4.0	18.3cd	4.8	15.3	3.9	0.4a	2.4
	Herdsman	2	100.0	0.0	19.2	3.7	100.0	0.0	4.7	4.4
	Housewife	365	40.5	2.6	2.9ab	5.9	23.3	2.2	0.9ab	3.4
	Laborer	1000	71.3	1.4	17.3cd	8.8	23.0	1.3	0.9ab	4.1
	Merchant	21	47.6	10.9	6.1abc	9.8	38.1	10.6	2.2ab	6.0
	Military	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Policeman	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Priest	14	78.6	11.0	36.4d	10.0	42.9	13.2	4.4b	7.9
	Prostitute	48	52.1	7.2	4.8ab	6.4	31.3	6.7	1.2ab	3.9
	Servant	124	61.3	4.4	7.4bc	6.4	34.7	4.3	1.5ab	3.9
	Student	291	34.4	2.8	2.2ab	5.5	22.7	2.5	0.7ab	3.0
	Teacher	2	50.0	35.4	3.0	7.1	0.0	0.0	0.0	0.0
	Tribal Chief	0	-	-	-	-	-	-	-	-
	Truck Driver	7	14.3	13.2	0.9ab	5.7	14.3	13.2	0.5ab	3.2
	Unemployed	297	69.4	2.7	15.3cd	8.4	40.7	2.9	2.7ab	5.9
	Total	2359	60.9	1.0	9.9	8.8	26.2	0.9	1.1	4.2
			$X^2 = 256.93(10) P < 0.001$**				$X^2 = 60.18(10) P < 0.001$			

Table 16. Continued.

Population	Occupation	N	Body Lice %	Body Lice SE	Body Lice GM	Body Lice SD	Head Lice %	Head Lice SE	Head Lice GM	Head Lice SD
Towns	Beggar	182	86.8	2.5	36.8d	8.0	27.5	3.3	0.8a	3.4
	Clerk	7	42.9	18.7	1.9ab	3.8	0.0	0.0	0.0a	0.0
	Craftsman	15	40.0	12.6	3.9ab	8.2	6.7	6.5	0.2a	2.3
	Dresser	4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Farmer	458	72.9	2.1	8.3bc	5.5	23.8	2.0	0.6a	2.8
	Herdsman	86	67.4	5.1	3.4ab	4.5	23.3	4.6	0.6a	3.0
	Housewife	372	53.5	2.6	3.8ab	5.2	21.2	2.1	0.5a	2.6
	Laborer	265	76.2	2.6	12.3c	5.5	29.4	2.8	1.2a	3.7
	Merchant	46	52.2	7.4	4.1ab	6.6	19.6	5.9	0.6a	3.0
	Military	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Policeman	10	20.0	12.6	0.5a	2.5	0.0	0.0	0.0a	0.0
	Priest	16	68.8	11.6	4.9abc	5.2	0.0	0.0	0.0a	0.0
	Prostitute	20	10.0	6.7	0.3a	2.3	5.0	4.9	0.1a	1.5
	Servant	20	45.0	11.1	2.9ab	4.8	20.0	8.9	0.6a	2.8
	Student	531	49.9	2.2	2.5ab	4.5	29.9	2.0	0.5a	2.2
	Teacher	5	0.0	0.0	0.0a	0.0	0.0	0.0	0.0a	0.0
	Tribal Chief	3	66.7	27.2	1.9	2.6	0.0	0.0	0.0	0.0
	Truck Driver	1	100.0	0.0	10.0	0.0	0.0	0.0	0.0	0.0
	Unemployed	392	41.6	2.5	2.1ab	4.9	21.4	2.1	0.4a	2.3
	Total	2435	59.1	1.0	5.0	6.1	24.4	0.9	0.6	2.7
			$X^2 = 236.01(12) P<0.001$				$X^2 = 32.81(12) P<0.001$			

*Means followed by different letters are significantly different at the 5% level (Duncan's multiple range test); sample sizes less than 5 not included in the analysis.

**Chi-square test for equality of percentage prevalence for all occupations; sample sizes less than 10 not included in the analysis.

Table 17. Percentage prevalence (%) and geometric mean (GM) levels of body and head lice for migrants and settled persons in Addis Ababa and 49 towns.

Population	Variable	N	Body Lice %	Body Lice SE	Body Lice GM	Body Lice SD	Head Lice %	Head Lice SE	Head Lice GM	Head Lice SD
Addis Ababa	Migrant	310	78.7	2.3	20.0a*	6.8	25.5	2.5	0.9a	3.5
	Settled	2049	58.2	1.1	8.9b	8.9	26.3	1.0	1.2a	4.2
	Total	2359	60.9	1.0	9.9	8.8	26.2	0.9	1.1	4.2
			$X^2 = 45.96(1) P<0.001$**				$X^2 = 0.09(1)$NS			
Towns	Migrant	435	67.1	2.3	8.2a	5.9	22.1	2.0	0.7a	3.0
	Settled	2000	57.3	1.1	4.5b	6.1	24.9	1.0	0.6a	2.6
	Total	2435	59.1	1.0	5.0	6.1	24.4	0.9	0.6	2.7
			$X^2 = 23.49(1) P<0.001$				$X^2 = 1.55(1)$NS			

*Means followed by different letters are significantly different at the 5% level (Duncan's multiple range test).

**Chi-square test for equality of percentage prevalence for migrants and settled persons.

cept for head lice in the Addis Ababa population (Table 18).

As shown in Appendix Table 7, rural residents washed their clothes less often than urban residents. This difference was significant and may reflect the fact that water was often more scarce or difficult to obtain in the countryside than in many of the more urban centers.

Our results for head lice differ from those reported by other workers including Mellanby (1941) and Donaldson (1976) who found head louse infestations to be more prevalent in urban than rural areas of England.

Dwelling Place

Table 19 shows the prevalence and density of head and body lice by dwelling place for the Addis Ababa and town populations. Of particular interest is the extraordinarily high prevalence and levels of body and head lice associated with churches, hotels, porches and tents. The more destitute persons examined lived in these places which were generally dirty and insanitary.

In Addis Ababa, these high risk dwelling places were concentrated in one very poor area near the Mercato or market area where the people slept in crowded hotel rooms or outside on porches or balconies. A majority of the LBRF patients studied in NAMRU-5 were also from this area.

The high levels of pediculosis associated with churches can be attributed to the beggars which were attracted to these facilities to beg and seek refuge at night.

Crowding

To determine the effects of crowding on pediculosis, the subjects in the study were questioned as to the number of persons they shared a room with at night. Of the 2,483 persons sampled from the Addis Ababa and town populations, most (88%) shared a room with 1-10 persons. The prevalence and mean levels of head and body lice were determined for different crowding levels. However, there was no obvious trend indicating that increased crowding had an affect on head or body louse infestations.

The effects of crowding on enhancing head and body louse transmission has been noted by different workers including Buxton (1947) and Slonka *et al.* (1976, 1977). We had anticipated increased crowding and pediculosis to be linearily related in this present study. That this did not materialize suggests that crowding within dwelling places was less important than other factors which influence pediculosis.

Personal Hygiene

The effect of clothes washing and changing on body louse populations was assessed for the three sample populations (Table 20). Overall, as the frequency of clothes washing and changing increased, the prevalence and density of body lice decreased significantly.

The most dramatic decrease in prevalence and density of body lice occurred when clothes were washed or changed once a week. Of the individuals examined from the three sample populations, 31% and 34% washed or changed their clothes, respectively, at or above this threshold level.

The correlation between lousiness and personal hygiene habits (clothes washing and changing) has been mentioned in the literature (Nuttall, 1917; MacLeod and Craufurd-Benson, 1941; Busvine, 1969). Our results quantify these statements for the first time.

In the highlands, rural settlements are frequently situated on hilltops or on well-drained slopes. Because of the threat of flooding and malaria, they are seldom found along streams or other low-lying areas. This pattern of locating villages away from watercourses usually applies even in the lowlands where the climate is arid and water sources are very limited. Under such circumstances, water must be transported considerable distances from streams, rivers, lakes or shallow wells for household purposes. Most commonly, this task is performed by Ethiopian women who carry the water in earthern pots on their backs from the nearest source (Fig. 19). These jugs hold up to 20 liters of water and the distance which must be traveled varies from a few

Table 18. Percentage prevalence (%) and geometric mean (GM) levels of body and head lice by residence for Addis Ababa and 49 towns.

Population	Residence	N	Body Lice %	Body Lice SE	Body Lice GM	Body Lice SD	Head Lice %	Head Lice SE	Head Lice GM	Head Lice SD
Addis Ababa	Rural	90	90.0	3.2	37.0a*	5.0	43.3	5.2	2.5a	5.2
	Urban	1349	61.8	1.3	11.7b	9.5	37.0	1.3	2.2a	5.3
	Total	1439	63.6	1.3	12.6	9.3	37.4	1.3	2.2	5.3
			$X^2 = 28.93(1)P<0.001$**				$X^2 = 1.45(1)$NS			
Towns	Rural	596	70.6	1.9	7.6a	5.4	37.9	2.0	1.4a	3.6
	Urban	448	38.2	2.3	2.5b	6.0	23.0	2.0	0.7b	3.0
	Total	1044	56.7	1.5	4.9	6.0	31.5	1.4	1.0	3.4
			$X^2 = 108.63(1)P<0.001$				$X^2 = 25.84(1)P<0.001$			

*Means followed by different letters are significantly different at the 5% level (Duncan's multiple range test).

**Chi-square test for equality of percentage prevalence for rural and urban residence.

Table 19. Percentage prevalence (%) and geometric mean (GM) levels of body and head lice by dwelling place for Addis Ababa and 49 towns.

Population	Dwelling Place	N	Body Lice %	Body Lice SE	Body Lice GM	Body Lice SD	Head Lice %	Head Lice SE	Head Lice GM	Head Lice SD
Addis Ababa	Church	24	100.0	0.0	262.0a*	3.4	70.8	9.3	23.0a	7.0
	Dormitory	6	50.0	20.4	7.3b	13.0	16.7	15.2	0.1b	1.3
	Hotel	50	98.0	2.0	191.7a	3.8	64.0	6.8	11.8c	8.4
	Modern House	100	67.0	4.7	11.0b	7.4	23.0	4.2	0.8b	3.5
	Mud Shack	1137	57.9	1.5	8.7b	8.5	35.2	1.4	1.8b	4.6
	Porch	44	100.0	0.0	279.1a	2.9	75.0	6.5	23.5a	8.1
	Tent	0	-	-	-	-	-	-	-	-
	Tukul	78	89.7	3.4	31.0b	4.7	41.0	5.6	2.1b	4.6
	Total	1439	63.6	1.3	12.6	9.3	37.4	1.3	2.2	5.3
			$X^2 = 102.97(5) P<0.001$**				$X^2 = 67.96(5) P<0.001$			
Towns	Church	5	100.0	0.0	433.2a	4.7	60.0	21.9	12.3ab	10.9
	Dormitory	4	25.0	21.7	2.2	10.1	25.0	21.7	1.8	7.8
	Hotel	4	50.0	25.0	9.6	16.6	25.0	21.7	1.3	5.1
	Modern House	192	39.1	3.5	2.2b	5.0	14.1	2.5	0.4c	2.7
	Mud Shack	300	51.3	2.9	4.5c	6.0	24.7	2.5	0.8d	3.2
	Porch	14	100.0	0.0	154.1a	2.5	92.9	6.9	27.1a	3.1
	Tent	11	100.0	0.0	22.5d	2.0	63.6	14.5	4.3b	4.0
	Tukul	514	64.2	2.1	5.5c	5.4	39.5	2.2	1.2e	3.3
	Total	1044	56.7	1.5	4.9	6.0	31.5	1.4	1.0	3.4
			$X^2 = 57.32(4) P<0.001$				$X^2 = 78.56(4) P<0.001$			

*Means followed by different letters are significantly different at the 5% level (Duncan's multiple range test); sample sizes less than 5 not included in the analysis.

**Chi-square tests for equality of percentage prevalence for all dwelling places; sample sizes less than 10 not included in the analysis.

hundred meters to one kilometer or more. In the more urban towns, water may be drawn from public wells or hydrants and carried to homes in open containers. In smaller towns and villages, and especially during the dry season, water may be transported by donkey from a distant water source to the town and sold in small quantities. In some instances, barrels of water are rolled along the road to a town for the same purpose (Fig. 20).

Because water sources are inadequate or not readily available, many of the people in Ethiopia have little option but to remain dirty. Water is used mainly for cooking and drinking purposes and cannot be wasted on washing. Similar conditions have been described elsewhere including certain villages in Uganda where the people remain lousy and dirty and recent typhus outbreaks have occurred (Sezi *et al.*, 1972).

When clothes are washed, the process is normally done by hand on rocks in cold water in the nearest source available. When finished, the garments are laid to dry on rocks, shrubs or the ground. Most of the people examined (76%) washed with locally made soap and others used no agent at all (18%). A few (6%) used certain plants as soap substitutes especially berries of the soapberry or endod *(Phytolacca dodecandra)*.

It is clear from the results obtained that clothes washing frequency can have a decided effect on louse populations. There is evidence which suggests, however, that the practice of washing clothes in cold water and drying them in the sun usually results in cleaner but still lousy apparel. Incomplete mortality of body lice and nits was reported by Moore (1918) when clothes were laundered in water at temperatures below 45°C. In his discussion of the subject, Buxton (1947) stated: " . . . the Egyptian peasant whose clothes are very lousy, washes them and himself in the canal almost every day." Body lice and nits have also been found to survive on clothing exposed to direct sunlight in tropical temperatures as high as 37°C (Cragg, 1922).

These observations were confirmed in a trial which we conducted. A shamma (the toga-like garment worn by both men and women) infested with about 200 nymph and adult body lice was washed in the Ethiopian manner using cold water (15°C) and a locally manufactured soap. After five minutes, it was wrung nearly dry and examined. The lice were all found clinging to the fibers but in an immobile and seemingly "stunned" state. After 1-2 minutes, about 98% of them recovered and became active. The garment was held overnight in an environmental chamber (26°C, 60% relative humidity). The following day, the shamma was spread out on the grass in direct sunlight to dry (maximum ambient temperature = 22°C). It was periodically turned to facilitate drying at which time the lice were observed to crawl to the underneath and shaded side. After about four hours, the dried garment was returned to the environmental chamber. On the following day, the shamma was examined and about 85% of the lice were found to be alive. There was also evidence of recent oviposition.

Accumulating evidence suggests that the inability of many Ethiopians to change their clothes frequently and laundry them adequately is largely responsible for the widespread prevalence of body lice.

FREQUENCY DISTRIBUTION OF INFESTATIONS

The frequency distributions of head and body louse infestations were calculated for 4,794 males and females from the Addis Ababa and town populations. Of the 2,876 persons infested with body lice, a majority (84%) had from 1-100 lice; the mode (27%) being between 1-12 lice. A small proportion (0.5%) had more than 1,600 body lice (Fig. 21). Of the 1,212 persons infested with head lice, a majority (78%) had from 1-25 lice; the mode (57%) being between 1-12 head lice. Two individuals (0.2%) had more than 800 head lice (Fig. 22).

Frequency distribution calculations for prisoners showed a similar trend as for the non-prisoners above. Of the 527 prisoners infested with body lice, 86% had from 1-100 lice; the mode (29%) being between 1-12 lice. Of the 77 prisoners infested with head lice, 67% had from 1-12 lice.

The highest counts of body or head lice encountered on any one individual were found on

Table 20. Percentage prevalence (%) and geometric mean (GM) levels of body lice for different rates that clothes were washed and changed by individuals in Addis Ababa, 49 towns and 23 prisons.

		Body Louse Results for Differences in Rates for:									
		Clothes Washed					Clothes Changed				
Population	Rate/Year	N	%	SE	GM	SD	N	%	SE	GM	SD
Addis Ababa	0	162	96.9	1.4	170.1a*	4.3	193	96.4	1.3	111.1a	4.7
	1-8	336	96.1	1.1	91.1b	4.8	422	91.2	1.4	58.7b	5.6
	12	720	80.8	1.5	19.1c	5.6	131	80.2	3.5	17.9c	5.0
	24	330	64.2	2.6	6.5d	5.1	201	69.2	3.3	7.9d	4.9
	52	808	20.0	1.4	0.7e	3.3	423	21.3	2.0	0.9e	3.6
	104+	3	33.3	27.2	3.7	14.4	69	14.5	4.2	0.5e	3.0
	Total	2359	60.9	1.0	9.9	8.8	1439	63.6	1.3	12.6	9.3
			$X^2_T = 951.99(4) P<0.001$**					$X^2_T = 645.64(5) P<0.001$			
			$X^2_r = 948.20(1) P<0.001$					$X^2_r = 559.62(1) P<0.001$			
			$X^2_d = 3.79(3)$ NS					$X^2_d = 86.02(4) P<0.001$			
Towns	0	133	83.5	3.2	35.0a	8.3	169	71.6	3.5	5.4a	6.7
	1-8	284	79.9	2.4	16.4b	6.6	232	81.9	2.5	19.9b	5.4
	12	744	76.5	1.6	8.3c	5.4	98	92.9	2.6	17.5b	3.2
	24	421	67.5	2.3	5.8d	4.6	106	71.7	4.4	8.2a	4.8
	52	700	32.7	1.8	1.3e	3.9	260	31.2	2.9	1.5c	4.1
	104+	107	14.0	3.4	0.3f	2.2	96	15.6	3.7	0.6d	3.1
	Total	2389	60.1	1.0	5.2	6.1	961	59.7	1.6	5.7	6.1
			$X^2_T = 483.74(5) P<0.001$					$X^2_T = 274.19(5) P<0.001$			
			$X^2_r = 441.86(1) P<0.001$					$X^2_r = 223.42(1) P<0.001$			
			$X^2_d = 41.88(4) P<0.001$					$X^2_d = 50.77(4) P<0.001$			

Table 20. Continued.

		Body Louse Results for Differences in Rates for:									
		Clothes Washed					Clothes Changed				
Population	Rate/Year	N	%	SE	GM	SD	N	%	SE	GM	SD
Prisons	0	44	97.7	2.3	52.5a	5.1	34	79.4	6.9	31.8a	7.9
	1-8	201	80.6	2.8	11.1b	7.0	77	80.5	4.5	11.4b	6.7
	12	167	83.2	2.9	21.2c	5.4	3	33.3	27.2	1.8	5.8
	24	205	75.1	3.0	12.2b	6.2	12	100.0	0.0	44.6a	1.8
	52	77	32.5	5.3	1.5d	4.7	11	27.3	13.4	0.9c	3.7
	104+	4	100.0	0.0	12.9	4.2	2	50.0	35.4	2.3	5.4
	Total	698	75.5	1.6	12.2	6.8	139	76.3	3.6	13.4	7.3
			$X^2_T = 96.48(4) P<0.001$					$X^2_T = 19.91(3) P<0.001$			
			$X^2_r = 81.58(1) P<0.001$					$X^2_r = 9.20(1) P<0.002$			
			$X^2_d = 14.90(3) P<0.002$					$X^2_d = 0.71(2) P<0.005$			

*Means followed by different letters are significantly different at the 5% level (Duncan's multiple range test). Sample sizes less than 5 not included in the analysis.

**Chi-square tests for equality of percentage prevalence for all rates per year: X^2_T = standard chi-square; X^2_r = test for linearity; X^2_d = test for departure from linearity. Sample sizes less than 10 not included in the analysis.

Figure 19. Amhara woman carrying a 20 liter jug of water to be used for cooking and drinking purposes.

Figure 20. Barrel of water from a lake source being transported by hand to a town several kilometers away. This may be commonly seen in some areas during the dry season when water sources become limited.

patients from the hospital study: An 80-year old male beggar who had a body louse burden of over 21,500 body lice and a 26 year old unemployed male with 2,167 head lice.

Our results also revealed that one might expect to find the heaviest infestations of head or body lice on males rather than females (Figs. 21 and 22).

The distribution of body lice was studied on British troops serving in France during World War I. Of those examined, 274 (95%) averaged 20 lice per man while about 5% had 100-300 lice (Peacock, 1916). In their studies of body lice on the undergarments of men living in common lodging-houses in England, MacLeod and Craufurd-Benson (1941) reported that the majority of the 151 persons infested had 1-10 lice, 15% had counts of over 100 lice and only two persons had more than 1000 body lice. Shawarby (1953) found an average of 1.2 body lice on 4,384 persons examined in a rural area of Egypt.

Buxton (1947) examined hair crops from 2,962 persons in six locations in Africa and Asia and found that a majority of those infested had only 1-10 head lice. Similar results were found by Mellanby (1942a) who examined 93 children in England. Marples (1965) commented on the similarity of these results (Buxton and Mellanby) from two very disparate communities stating: "It seems clear that humans readily tolerate a small number of these ectoparasites, and no doubt light infestations are not recognized by the host." Busvine (1969) has stated:

> The fact that the most common infestation is only of 10-20 insects is of considerable interest. It means that

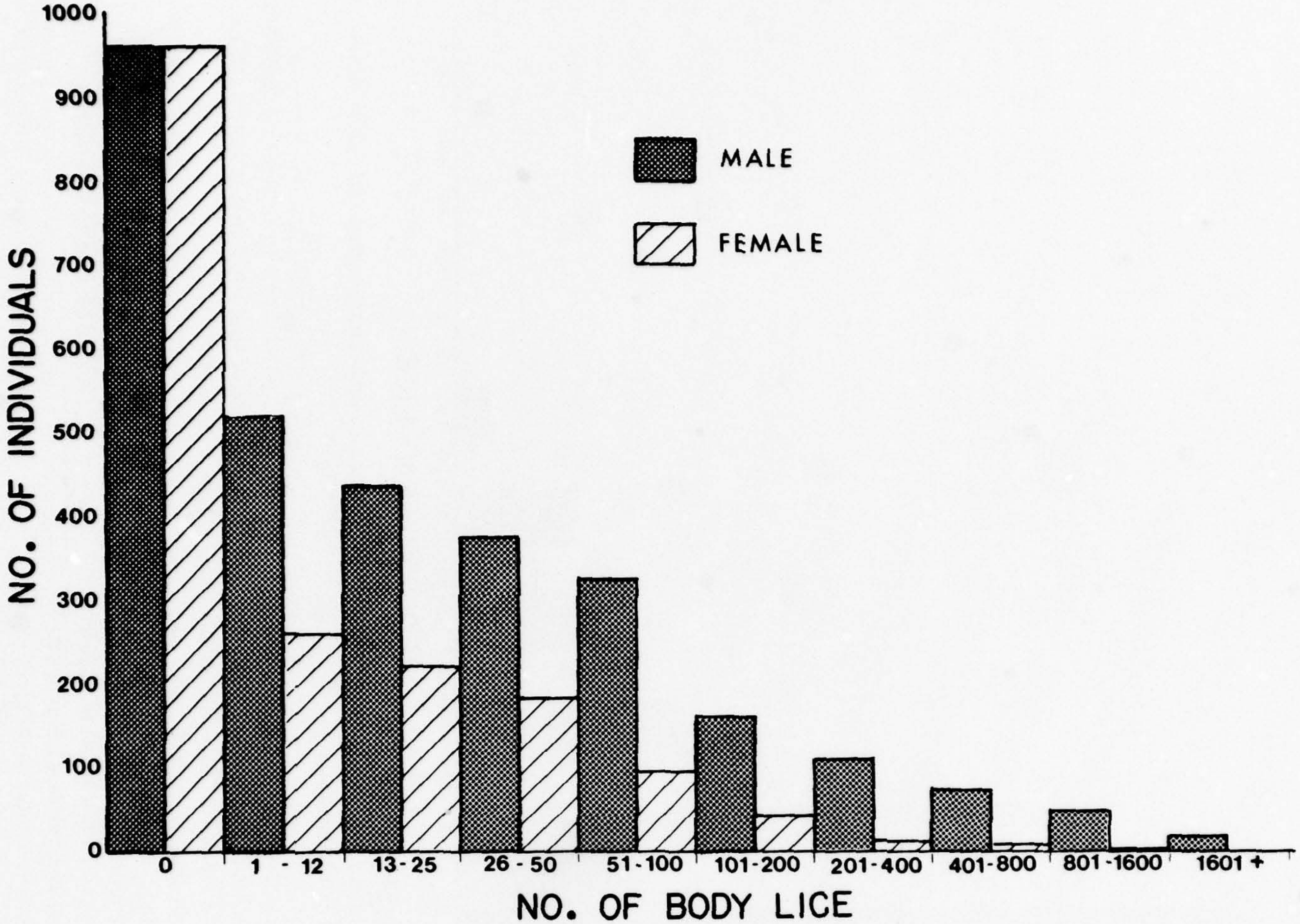

Figure 21. Frequency distribution of body lice in 4,794 males and females from the Addis Ababa and town populations.

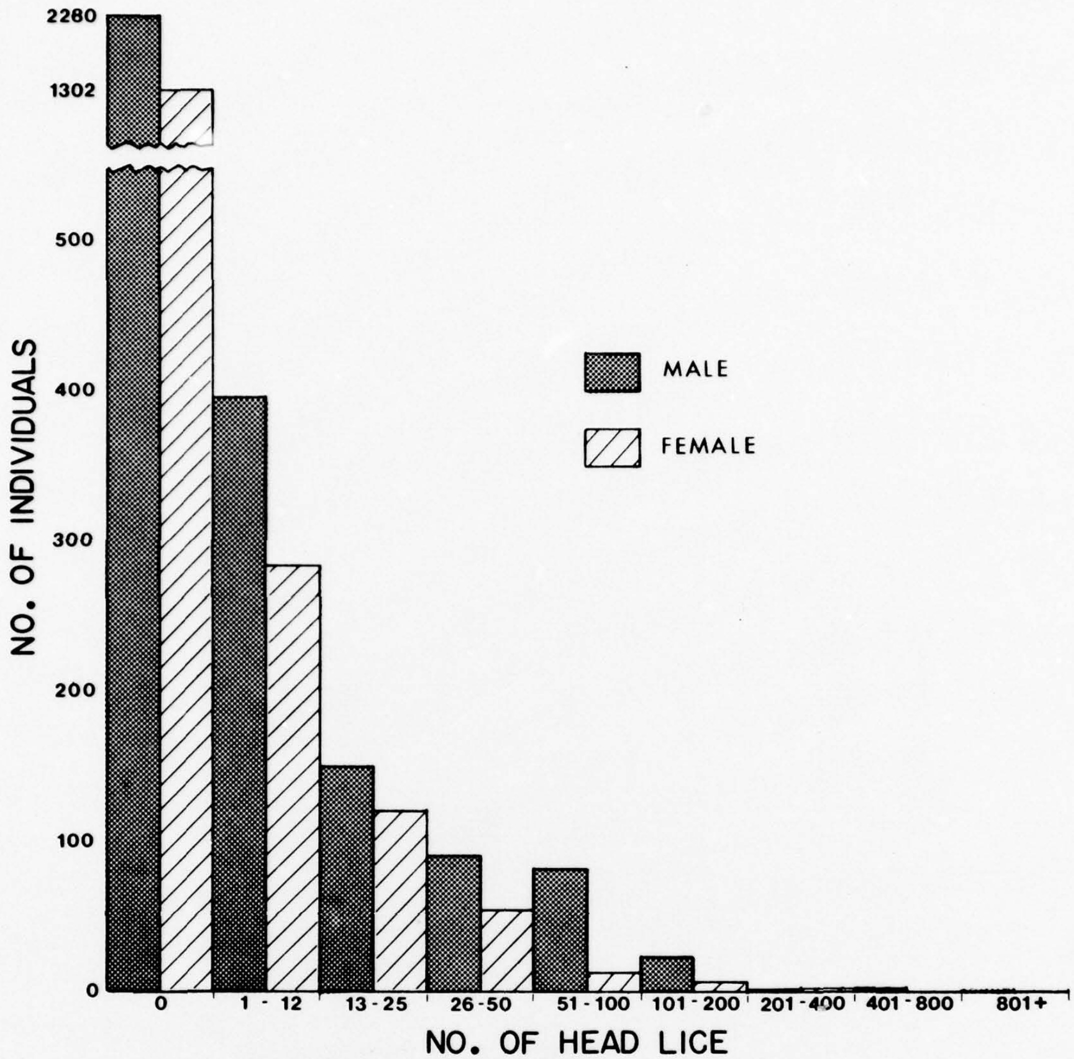

Figure 22. Frequency distribution of head lice in 4,794 males and females from the Addis Ababa and town populations.

there is very large mortality due, no doubt, to the host's reactions to the irritation caused by their bites. It seems very probable that habitually lousy individuals have each a characteristic normal louse population and that a 20-louse man would only become a 200-louse man as the result of some very radical change in his habits enforced by some outside influence.

Our results are more complete and extensive than those previously reported in the literature, and they confirm the above observations that low levels of head and body lice are most commonly found on human hosts.

DOUBLE INFESTATIONS

The opportunities to study individuals with simultaneous infestations of head and body lice are quite limited in modern societies where the body louse is rarely encountered. The information is of interest since little has been published on the

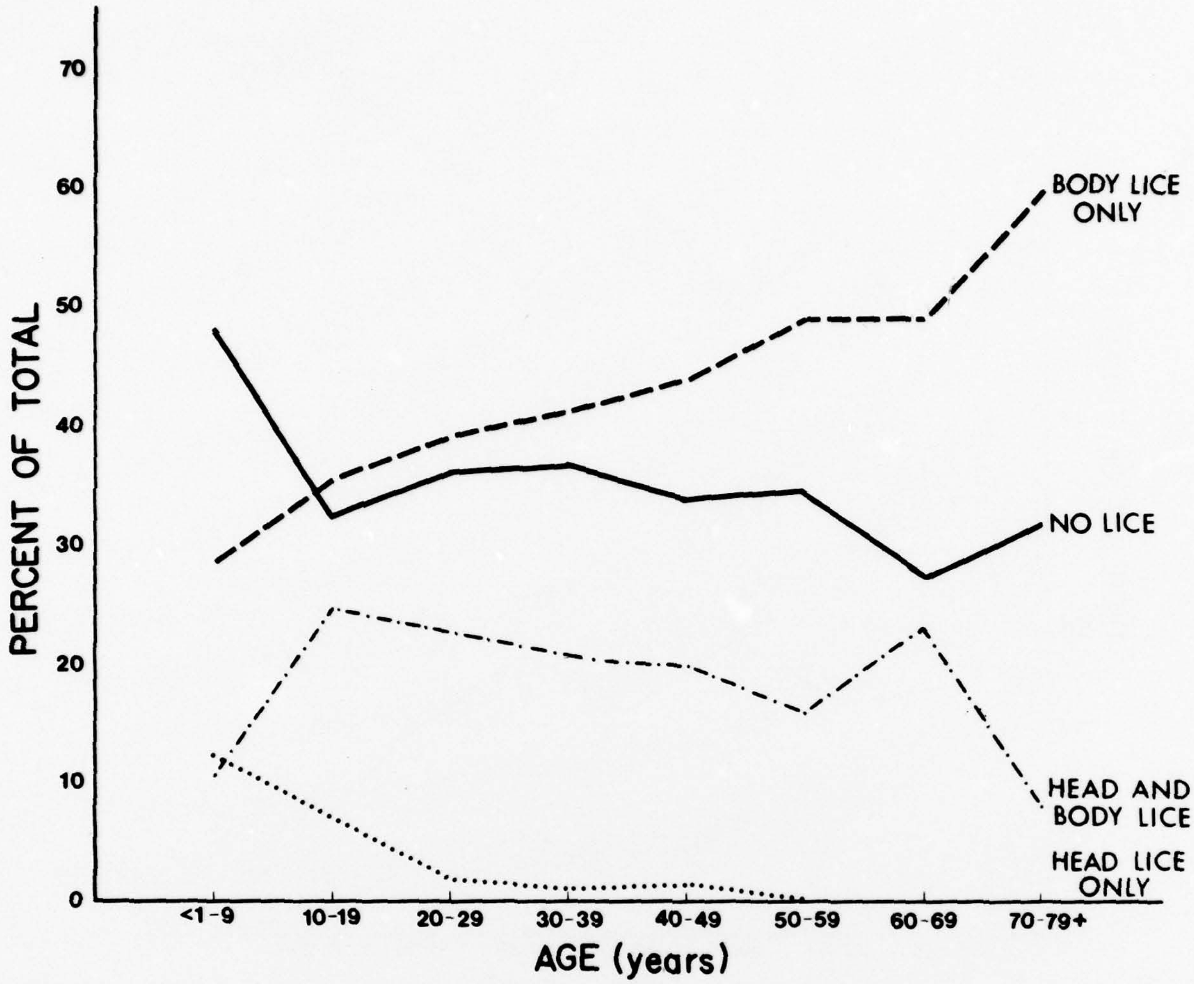

Figure 23. Percentage prevalence of individuals infested with head lice only, body lice only, both head and body lice, and non-infested persons by age group for 4,794 individuals from the Addis Ababa and town populations.

subject in the past. At the time of World War I, Hase (1915a) examined 1000 poor people in Poland and found double infestations in 13% of the children, 35% of the women and 29% of the men.

The percentage prevalence of individuals infested with head lice only, body lice only, both head and body lice, and non-infested persons were calculated by age class for 4,794 non-prisoners (Addis Ababa and town populations) and 698 prisoners. As shown in Figures 23 and 24, the proportion of individuals with only body lice increased with age while those with only head lice decreased with age. The proportion of persons with simultaneous infestations also decreased somewhat with age (this was less apparent in the prison population which had comparatively low head louse prevalence).

Figure 25 shows similar information calculated by sex. The proportion of males and females

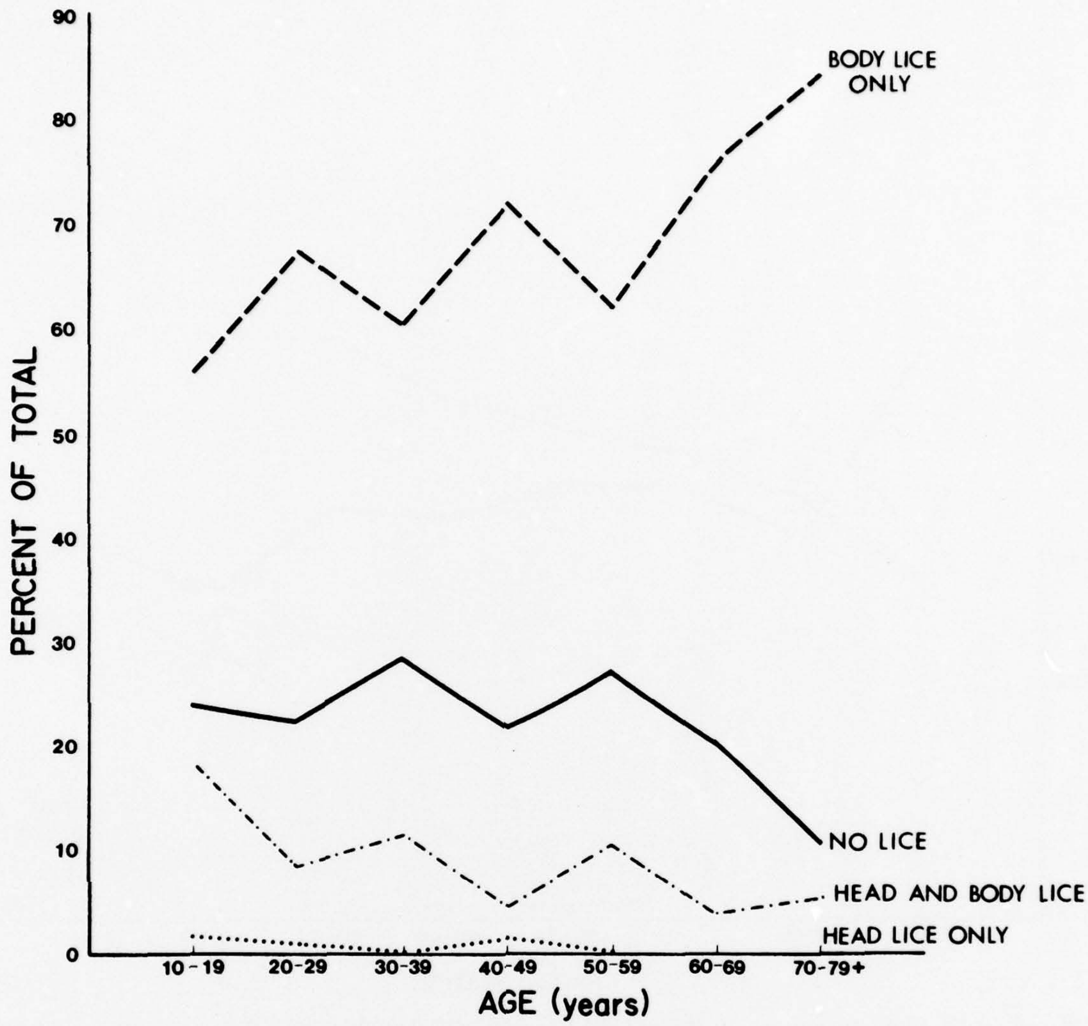

Figure 24. Percentage prevalence of individuals infested with head lice only, body lice only, both head and body lice, and non-infested persons by age group for 698 prisoners.

with double infestations is nearly the same for both non-prisoners and prisoners. The proportion of females with only head lice was higher than that for males while the reverse was true of body lice.

The highest double infestation encountered was on a 26 year old unemployed male patient in the hospital study who had 10,777 body lice and 2,167 head lice. For a female, the highest was on a 14 year old unemployed patient who had 1,181 body lice and 918 head lice.

CRAB LICE

Because of the high prevalence of head and body lice in addition to the high incidence of venereal diseases in Ethiopia, it was of interest to find that crab lice were rarely found on individuals in this investigation. Of the 386 persons examined during the hospital study, only one patient was found to be infested; a 15-year-old male who had a total of 35 crab lice.

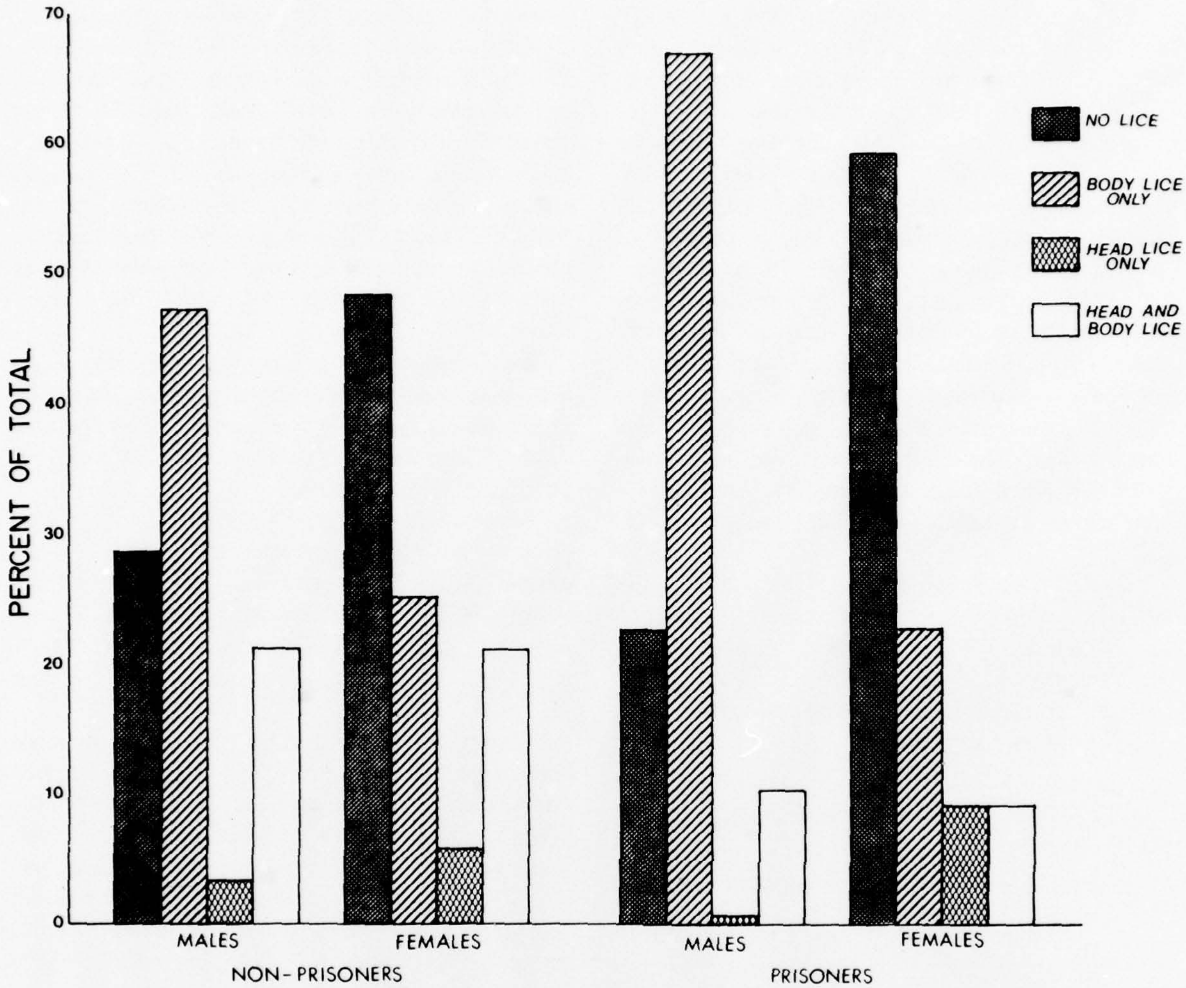

Figure 25. Percentage prevalence of non-prisoners and prisoners infested with head lice only, body lice only, both head and body lice, and non-infested persons by sex.

It was seldom possible to examine for crab lice during the field surveys. Arrangements were made, therefore, to conduct a limited study at the Addis Ababa Venereal Disease Clinic. Of 251 individuals examined (77 females, 174 males), the only positive case found was a 25 year old female infested with 5 crab lice.

Of the VD patients examined, 46% had recently shaved their pubic region; a practice done about once a month by both sexes for aesthetic and hygienic purposes. Fisher and Morton (1970) reported a rising incidence of crab louse infestations in the United Kingdom but noted that the lice were relatively rare in "Mohammedans" who regularly shaved the pubis and axillae. Our observations suggest that a similar phenomenon occurs in Ethiopia.

HOSPITAL STUDY

The 386 volunteers examined in the hospital study were categorized into two major groups according to their socioeconomic status, personal hygiene habits, general health status and state of lousiness: A control group (CONT) and a study group (STDY).

The CONT group included 210 relatively healthy and non-lousy subjects, most of whom belonged to the upper lower class or emerging middle class of Ethiopia. These individuals included student nurses (24%), domestic servants (23%), professional and skilled workers (18%), laboratory technicians (10%), hospital medical staff (10%), housewives (8%) and others (7%).

The STDY group included 176 healthy and diseased volunteers who were primarily members of the lower socioeconomic class; all but seven were lousy to some degree. They included laborers (68%), skilled workers (8%), unemployed (8%), beggars (6%), domestic servants (3%) and others (7%). The STDY group was further divided into three subgroups: healthy (WELL), relapsing fever (LBRF) and mixed infections (MISC).

The WELL group included 55 subjects not suffering from any major disease. The LBRF group included 79 individuals diagnosed as having louse-borne relapsing fever. The MISC group included 42 subjects diagnosed as having eight different illnesses (Table 21).

Table 21. Disease diagnosis for 42 patients in the MISC subgroup.

Diagnosis	N
Leprosy	14
Pneumonia	8
FUO[a]	5
Influenza	5
Typhoid Fever	5
Malaria	2
Typhus	2
Tuberculosis	1
Total	42

[a]Fever of undetermined origin

Table 22 lists comparative personal and socioeconomic information for patients in the study groups.

Head and body louse levels for the STDY subgroups are shown in Table 23. The geometric means for head and body lice were significantly higher than those found in the field surveys. This may be attributed to the fact that more detailed and accurate louse counts were possible by removal of all clothing and by shaving the patient's head. Additionally, a conscious effort was made to find and include heavily infested people in the study. This sampling bias was considered necessary if correlations between host physiological variables and their state of lousiness were to be found.

To facilitate the presentation, abbreviations have been used for the different physiological variables studied. These are shown in Appendix Table 8 together with units of measurement and published normal values.

In Appendix Tables 9-13, the results of the clinical and biochemical tests are summarized by patient groups and sex. Means and standard deviations are presented for the physiological variables along with significance tests for age and sex dependence and for differences between the groups.

The mean values for the CONT group were within published normal physiological ranges (Appendix Table 8). For the STDY subgroups, abnormal mean values occurred within the LBRF and male groups especially for liver function. These values were probably associated with the relapsing fever cases which occurred in both groups (Bryceson *et al.*, 1970; Felsenfeld, 1971; Salih *et al.*, 1977).

Correlation coefficients (r) and scattergrams (subprogram SCATTERGRAM) were determined between head and body louse levels and the different physiological variables. The results are listed in Appendix Tables 14-17. Correlations which were significant at $P < 0.05$ are summarized by patient group and sex for head lice (Table 24) and body lice (Table 25) and discussed in more detail below.

Copplestone (1975) and May (1950) discussed the problems of analyzing comparative data and stressed the danger of interpreting a significant difference between variables when, in fact, no significance exists. This is especially true of exploratory investigations of this type where many of the physiological variables examined may be age or sex dependent, or interrelated be-

Table 22. Selected personal and socioeconomic data for volunteer patients.

Patient Group	N	Median Age	Sex M/F	Median Income/Month $ Ethiopian[a]	Median Educational Level	Median Times Clothes Washed/Year
CONT	210	27.2(16-70)[b]	97/113	50.3(0-1500)	10.5(0-20)	96.8(24-365)
STDY	176	26.9(13-80)	152/24	29.9(0- 175)	0.2(0-11)	12.2(0-104)
WELL	55	24.8(14-80)	43/12	29.8(0- 175)	0.1(0-11)	23.9(0-104)
LBRF	79	21.6(13-51)	76/3	30.3(0- 150)	0.2(0-10)	11.9(0- 52)
MISC	42	28.0(13-60)	33/9	29.3(0- 60)	0.2(0- 8)	12.3(0- 52)

[a]Two Ethiopian dollars equal about one U.S. dollar (1976).

[b]Range given in parenthesis.

Table 23. Geometric mean (GM) levels of body and head lice by patient subgroup.

Subgroup/ Diagnosis	Body Lice N	Body Lice GM	Body Lice SD	Head Lice N	Head Lice GM	Head Lice SD
WELL	55	45.9	18.9	26	23.9	6.0
LBRF	79	220.5	7.3	65	44.8	6.1
MISC	42	69.6	12.2	28	26.4	8.9
Influenza	5	167.8	4.0	5	14.7	7.0
FUO[a]	5	36.3	22.6	5	3.2	3.7
Leprosy	14	13.9	5.6	0	-	-
Malaria	2	469.9	18.0	2	29.6	6.7
Pneumonia	8	125.0	15.6	8	17.5	9.0
TB	1	210.9	-	1	4.0	-
Typhoid	5	313.0	25.2	5	251.2	3.1
Typhus	2	423.3	2.2	2	481.5	1.4
Total[b]	176	102.8	12.5	119	34.5	6.7

[a]Fever of undetermined origin

[b]Based on the three patient subgroups

tween each other. The associations described, therefore, may be exaggerated or diminished in unanticipated ways by variations within the patient groups. On the other hand, in epidemiologically oriented studies, even those results which are not statistically significant may indicate trends which should not be neglected since they can form a basis for future investigations (Copplestone, 1975). We have interpreted the following data with that in mind.

Hematological Variables

Mean hematological values for the STDY group were within normal limits except for platelets (PLAT) and erythrocyte sedimentation rate (ESR) which were abnormal in the LBRF group (Appendix Table 13).

As shown in Tables 24 and 25, negative correlations were found between louse levels and hemoglobin (HGB), hematocrit (HCT), white blood cell count (WBC), red blood cell count (RBC), prothrombin time (PT) and PLAT. Reticulocyte count (RETC) and mean corpuscular volume (MCV) were positively correlated with body lice but negatively correlated with head lice. Positive correlations between body lice, erythrocyte sedimentation rate (ESR) and mean corpuscular hemoglobin (MCH) were also found. Scattergrams showing better than average linear trends for hematological variables and louse

Table 24. Correlation coefficients for head louse levels and human physiological variables by patient subgroup.

	WELL		LBRF		MISC		Males		Females	
Variable	N	r	N	r	N	r	N	r	N	r
PPBS		NS		NS		NS		NS	11	.63*
ALKP	26	.35*		NS		NS		NS		NS
SGOT		NS		NS	27	.35*	106	.21*		NS
SGPT		NS		NS		NS	64	.29**		NS
BILT		NS		NS		NS	104	.18*		NS
BILD		NS		NS	28	.32*	105	.17*		NS
Na		NS		NS	20	.42*		NS		NS
K		NS		NS	20	.38*		NS		NS
Cl		NS		NS	20	.40*		NS		NS
Al		NS		NS	20	-.46*		NS		NS
Ca		NS		NS	21	-.50*	70	-.36***		NS
RETC		NS	59	-.25*		NS		NS		NS
PLAT		NS		NS		NS		NS	11	-.66*
PT		NS		NS	28	-.34*		NS		NS
MCV		NS	25	-.45*		NS	33	-.32*		NS

NS = Not Significant

*P<0.05; **P<0.01; ***P<0.001

Table 25. Correlation coefficients for body louse levels and human physiological variables by patient subgroup.

Variable	WELL		LBRF		MISC		Males		Females	
	N	r	N	r	N	r	N	r	N	r
TEMP		NS		NS	41	.28*		NS	23	.39*
HT	54	.29*		NS	41	-.28*		NS		NS
BIC		NS		NS		NS		NS	24	-.39*
TRIC	55	-.33**	70	-.29**	42	-.26*		NS		NS
BUN	55	.34**		NS		NS	152	.14*		NS
SGOT		NS		NS	41	.30*	150	.14*	23	.53**
SGPT		NS		NS	29	.39*		NS		NS
BILT		NS		NS		NS	148	.16*		NS
CHOL	55	-.23*		NS		NS		NS		NS
Cl		NS	57	-.23*		NS		NS		NS
ALB	39	-.48***		NS		NS	110	-.21*	17	-.44*
A1		NS	54	-.25*		NS		NS		NS
A2		NS		NS	34	.29*		NS		NS
P		NS	49	-.24*		NS		NS		NS
ESR		NS		NS		NS		NS	24	.38*
HGB	55	-.37**		NS		NS	152	-.22**	24	-.38*
HCT	55	-.32**		NS		NS	152	-.20**		NS
RETC	53	.32**		NS		NS	139	.19*		NS
WBC		NS	79	-.23*		NS		NS		NS
RBC		NS	31	-.31*		NS	60	-.29*		NS
MCV	23	.43*		NS	19	.47*		NS		NS
MCH		NS		NS	19	.54**		NS		NS
SKPH		NS	30	-.50**		NS		NS		NS
SKTEMP	21	-.43*		NS	18	.43*	46	.40**	13	-.51*
SWNa		NS		NS	16	.46*		NS		NS

NS = Not Significant

*$P<0.05$; **$P<0.01$; ***$P<0.001$

levels include those between body lice, RBC (LBRF) and MCV (MISC) and MCH (MISC), and between head lice and PLAT (Females). The hematological results suggest the possibility that louse infestations, particularly excessive ones, may cause anemia in the host.

Nelson *et al.* (1977) cites the work of Finkel (1933, 1934) who fed up to 38,000 lice on two human subjects monthly for nearly two years. Finkel observed significant decreases in RBC and HGB values of his volunteers. He also reported microcytosis, poikilocytosis, hypochromia and polychromasia in the individuals. This early work on anemia caused by an ectoparasite is the only detailed one for humans found in the literature. Nelson *et al.* (1977) also note that references to anemia caused by ectoparasites have been reported relatively frequently in the literature. They review a number of papers reporting anemia in livestock, laboratory, companion and wild animal species associated with a variety of ectoparasites.

Hematological values for males in the WELL group were averaged for 12 individuals with the highest louse counts ($\bar{x}=3{,}057$) and 12 individuals with the lowest ($\bar{x}=13$). The average age for the two groups was 28.4 and 29.6, respectively. Of the blood components considered, the mean values for HGB (13.6 ± 3.9 g/100 ml) and HCT ($41.2 \pm 12.6\%$) of the high louse group were at or near the lower limits of normal standards while those for the low louse group, HGB (16.4 ± 1.2 g/100 ml) and HCT ($49.2 \pm 3.7\%$), were within the normal ranges given by Gillum (1971): HGB 16-19g/100ml, HCT 45-56%. All of the other values considered (ESR, RETC, WBC, PLAT, MCHC) were within normal ranges for both high and low louse groups. There was also little difference between the group means for these values.

A male patient in the WELL group was found to have the highest burden of body lice detected during the investigation; estimated at over 21,500 nymph and adult lice. This subject was an 80-year-old beggar (Fig. 26) who had been blind for 32 years. Despite his age and large ectoparasite burden, the patient was considered to be in relatively good health and nutritional status by examining ward physicians. Because of his unusually large louse population, the subject was requested to return for re-admission at three-month intervals for a repetition of all laboratory tests and louse assessments. At each visit, the patient's clothes were heat-treated in a sterilizing unit to kill all nits and crawling stages. He was provided with insecticide dust and soap, and other efforts were made to improve his personal hygiene and sanitary conditions in the mud shack where he lived with three other persons.

Table 26 shows the results of the study of this elderly patient. Hypochromia and poikilocytosis of the RBC's were noted during his initial visit in September of 1975. At the four intervals, his values for ESR, HGB, HCT, RETC, WBC, RBC and MCHC were at or below normal limits. In spite of the efforts to control his louse populations, the patient continued to support relatively high louse levels as assessed at the three month intervals. The patient expired prior to his last scheduled visit in September 1976.

Table 26. Hematological values determined at three month intervals on an 80-year old male patient supporting unusually large body louse levels. Disinsection was done after each louse assessment.

Values	Sept. '75	Dec. '75	Mar. '76	June '76	Units
ESR	23	37	28	48	mm/hr
HGB	4.0	13.0	16.0	12.6	g/100 ml
HCT	19	40	48	38	%
RETC	0.5	0.6	0.6	0.5	%
WBC	5.1	5.6	4.4	5.4	$\times 10^3$/mm^3
RBC	-[a]	-	4.9	4.2	$\times 10^6$/mm^3
MCV	-	-	98	91	μ^3
MCH	-	-	33	30	pg
MCHC	21.0	32.5	34.0	34.0	%
PLAT	220	275	450	460	$\times 10^3$/mm^3
No. Lice	21500	1500	1125	2890	

[a]Poikilocytosis and hypochromasia of RBC's

Figure 26. Eighty-year old blind beggar found with more than 21,500 body lice in his clothing.

ABO Blood Group

An analysis of the data in Table 27 revealed a possible association between ABO blood groups and the degree of body louse infestations. For the total of 168 patients, the geometric mean of body lice for the AB group was nearly seven times that of the O group; a significant difference by ANOVA and Duncan's multiple range test ($P < 0.05$). Differences between the blood groups and mean louse levels were significant for females but not for males.

Correlations between head louse levels and ABO blood groups were not significantly different (Table 28). In male patients, however, ranking of the mean levels for head lice by blood group was similar to that for body lice (AB > B > A > O). The correlation coefficient between the means for body and head louse levels was only weakly positive ($N = 113$, $r = 0.33$, $P < 0.001$) indicating that double infestations on the same individual were not closely related.

The number of females examined was low and, in the case of body lice, the women were contributing to a significant ANOVA for total patients. The number of individuals in the AB group was also low, but this is compatible with previous studies on ABO blood group frequencies in Ethiopia (Schaller, 1972).

Personal and socioeconomic factors are summarized for the different ABO blood groups in Table 29. The differences which occur between patients in the groups are small and would not entirely explain the variations in louse levels.

For parasitic diseases, an association between *Giardia lamblia* incidence and blood group A has been reported by workers in Australia (Barnes and Kay, 1977) and in Brazil (Zisman, 1977). Also in Brazil, Camus *et al.* (1977) studied ABO blood groups in patients with two clinical forms of untreated *Schistosoma mansoni*. They found that blood group A occurred more frequently in patients with a severe hepatosplenic form of the disease while blood group O was more often found in those with a milder form of the disease. The authors suggested that a relationship may exist between the tendency to develop a severe disease and the blood group. Similar studies have been done on loiasis in West Africa (Ogunba, 1970) and trypanosomiasis in East Africa (Carter *et al.*, 1970), but no association between these diseases and ABO blood groups was found.

In laboratory studies, the preferential feeding of female mosquitoes on blood group O individuals has been reported in species A of the *Anopheles gambiae* complex (Wood *et al.*, 1972; Wood, 1974) and in *Aedes aegypti* (Wood, 1976). The basis for the reported preference for blood group O could not be explained in either instance.

It has been suggested that the various polymorphic distributions of human ABO blood groups in different regions of the world may have been influenced by the selection pressure of mosquitoes and mosquito-borne diseases such as malaria and yellow fever (Wood, 1975; Wood, 1976). Wood (1974) further suggested that the potential influence of insect vectors of human diseases in the selection of various human physiological variables requires more investigation. The validity of her studies has been challenged by Thornton *et al.* (1976) who were unable to duplicate Wood's findings in laboratory experiments using mosquitoes from the same colony of *Anopheles gambiae*.

Compared to the other physiological variables examined in the present study, ABO blood group was not influenced by nutritional status or disease state of the patients. Although our results show a very limited association between blood groups and louse infestation levels, this area of research is promising and should be studied further.

Biochemical Variables

Liver function variables including alkaline phosphatase (ALKP), serum glutamic oxaloacetic transaminase (SGOT), serum glutamic pyruvic transaminase (SGPT), and bilirubin (total, BILT; direct, BILD) were positively correlated with louse levels in certain of the patient subgroups (Tables 24 and 25). The LBRF group had significantly higher mean values for these biochemical variables (Appendix Table 13) but none were significantly correlated with body or head louse levels.

Positive correlations were found between louse levels and blood urea nitrogen (BUN), postprandial blood sugar (PPBS), sodium (Na), potassium

Table 27. Geometric mean (GM) levels of body lice by ABO blood group for 168 male and female patients in the STDY group.

Blood Group	Total			Male			Female		
	N	GM	SD	N	GM	SD	N	GM	SD
A	54	115.2ab*	10.3	46	192.7a	7.4	8	5.2a	7.0
B	39	129.7ab	11.5	36	126.5a	12.4	3	175.3b	5.2
AB	11	336.2a	10.2	10	453.6a	9.2	1	16.0ab	-
O	64	48.8b	14.3	53	84.4a	11.8	11	2.7a	7.1
Total	168	91.7	12.5	145	136.2	10.5	23	6.8	9.0
ANOVA	F=2.72; P=0.047			F=1.97; P=0.122			F=3.28; P=0.044		

*Means followed by different letters are significantly different at the 5% level (Duncan's multiple range test).

Table 28. Geometric mean (GM) levels of head lice by ABO blood group for 113 male and female patients in the STDY group.

Blood Group	Total			Male			Female		
	N	GM	SD	N	GM	SD	N	GM	SD
A	37	29.0a*	6.4	34	26.2a	6.6	3	89.7a	2.7
B	26	47.9a	10.4	25	42.5a	10.0	1	918.0a	-
AB	8	56.9a	9.0	7	54.8a	10.7	1	74.0a	-
O	42	26.4a	5.2	37	22.5a	5.3	5	82.6a	2.9
Total	113	33.0	6.8	103	29.4	7.0	10	106.7	3.1
ANOVA	F=0.74; P=0.530			F=0.75; P=0.524			F=1.60; P=0.285		

*Means followed by different letters are significantly different at the 5% level (Duncan's multiple range test).

Table 29. Selected personal and socioeconomic data by blood group for 168 patients in the STDY group.

Blood Group	N	Median Age	Sex M/F	Median Income/Month $ Ethiopian[a]	Median Educational Level	Median Times Clothes Washed/Year
A	54	23.5(13-60)[b]	46/8	30.0(0-175)	0.2(0-10)	23.6(0-104)
B	39	23.2(14-79)	36/3	30.1(0-150)	0.2(0-10)	12.2(0- 52)
AB	11	24.0(16-70)	10/1	30.4(20-60)	0.1(0- 2)	12.2(4- 52)
O	64	23.5(13-80)	53/11	29.8(0-100)	0.2(0- 9)	12.1(0-104)

[a]Two Ethiopian dollars equal about one U.S. dollar (1976).

[b]Range given in parenthesis.

(K) and alpha-2 globulin (A2). Calcium (Ca,), cholesterol (CHOL), albumin (ALB), phosphorus (P), and alpha-1 globulin (A1) showed negative correlations with louse levels for some groups. Chloride (Cl) was positively correlated with head louse levels in the MISC group but negatively correlated with body louse levels in the LBRF group (Tables 24 and 25).

Of interest were the correlation coefficients between PPBS and head louse levels in females ($r=0.63$) and for ALB and body louse levels in the WELL group ($r=-0.48$). Scattergrams for these variables showed better than average linear trends. PPBS and ALB may be related to undernutrition while ALB is associated with dehydration and a number of pathological states. This was not as significant a problem in the WELL group compared to the LBRF and MISC groups.

O'Kelly and Spiers (1976) studied the effects of tick burdens on blood composition of cattle and found that total tick numbers were negatively correlated with concentrations of serum ALB, CHOL and total protein (TP) in the animals. While their results are not strictly comparable to those found in humans infested with lice, further study of certain of the biochemical values such as ALB would be of interest.

Intestinal Parasites

Appendix Table 18 lists the results of the stool examinations for ova and parasites. A total of 14 different parasites or their ova were isolated from 364 patients. Those pathogenic parasites most commonly found included *Ascaris lumbricoides, Trichuris trichiura, Strongyloides stercoralis, Taenia saginata* and hookworms *(Ancylostoma, Necator)*.

Parasite prevalence was not found to be significantly correlated with age or sex in either the CONT or STDY groups. Parasite prevalence was weakly correlated with body louse levels in male patients of the STDY group only ($N=140$, $r=0.15$, $P=0.042$).

Of the two patient groups, more than 50% of the subjects in the CONT group were free of intestinal parasites compared to 23% in the STDY group. Double and multiple infestations also occurred more frequently in the STDY group (Appendix Table 19). Of interest was a 30 year old male laborer suffering from lepromatous leprosy whose parasite burden included *Iodamoeba buetschlii, Entamoeba coli, S. stercoralis, A. lumbricoides, T. trichiura* and *T. saginata*, in addition to more than 100 body lice.

The greater number of infestations in the STDY group probably reflects the lower personal hygiene and sanitation standards which promoted the acquisition of both human lice and intestinal parasites. The influence of the intestinal parasites on the physiological variables observed deserves further study.

Detailed information on intestinal parasites and their incidence in Ethiopia can be found in Molineaux (1967), Schaller (1972), and Armstrong and Chane (1975).

Anthropometric Variables

Means for all of the anthropometric variables except height (HT) were significantly greater for the CONT group ($P < 0.001$) as shown in Appendix Table 9. This reflects the results of the physical exams which indicated that the CONT patients were generally better nourished than the STDY patients.

There were no significant correlations between head lice and any of the anthropometric variables (Table 24). For body lice, however, significant but weak negative correlations were found for biceps (BIC) in females and triceps (TRIC) skinfold measurements in all three patient subgroups (Table 25).

A number of different factors may affect skinfold variables including age, sex, ethnic and socioeconomic differences (Jelliffe, 1966). In the STDY group (Appendix Table 12), skinfold measurements were significantly higher in females than males ($P < 0.001$). Correlations between skinfold variables and age were not, however, significantly different except for subscapular (SUBS) (Appendix Table 10).

The subjects in this study, particularly those with high louse infestations, were mostly poor, uneducated and single young men. They generally lived crowded together in unhygienic conditions and earned a precarious living as day laborers. Such conditions would likely expose them to repeated louse infestations and promote existing ones. Those

individuals with relatively high body and head louse counts (1000+), however, were not found by physical examination to be malnourished. The existence of a causal relationship between subcutaneous fat deposits and lousiness cannot be proven by the results of this investigation.

Skin pH

As shown in Appendix Tables 9-13, differences found in mean skin pH (SKPH) values were not significant for the patient groups examined, except between males and females in the CONT group. There was also a weak negative correlation ($r = -0.17$, $P < 0.008$) between SKPH and age in the CONT group. The mean pH values for all of the subgroups were within the upper limits of the published normal range of 4.5-5.8 (Behrendt and Green, 1971).

A highly significant and negative correlation between body louse levels and SKPH was found in the LBRF group (Table 25). The scattergram for these two variables also showed a more obviously linear trend than any of the other physiological variables considered in this study.

Determining whether a causal relationship exists between SKPH and lousiness is a complex problem because of the variety of factors which may influence the H-ion concentration activity in the skin's surface emulsion. Such factors have been discussed in depth elsewhere (Marples, 1965; Behrendt and Green, 1971) and include: age, sex, environment, skin site, body temperature, skin temperature, sweating rate and pathological affects.

The variation in mean SKPH values for individuals in the LBRF group were not significantly different from the WELL and MISC groups (Appendix Table 13). Mean skin temperature values were, however, significantly different between the subgroups ($P < 0.001$); being highest for the LBRF group (Appendix Table 13).

No significant correlations were found between SKPH and skin temperature for any of the patient subgroups including the LBRF group ($r = 0.33$, $P = 0.076$). Skin temperature measurements, however, were available for only 20 of the 30 patients sampled for SKPH. Correlation coefficients between SKPH, sweat NaCl and rectal temperatures were not significantly different for either the LBRF group or the other patient subgroups.

Behrendt and Green (1971) believed that abnormal pH patterns rarely occur but when found usually may be associated with skin trauma or some pathological condition. Under the conditions of this study and the low number of individuals sampled, the association between SKPH and lousiness is difficult to assess.

Skin and Body Temperatures

As shown in Table 25, correlation coefficients determined between skin temperature (SKTEMP) and louse levels were positive for body lice and the MISC and male groups, but negative for the WELL and female groups. Body temperature (TEMP) and body louse levels were positively correlated for the MISC and female groups. A significant correlation was also found between SKTEMP and body temperature for the MISC group ($N = 17$, $r = 0.80$, $P < 0.001$) but not for the other subgroups. Mean SKTEMP and body temperatures were highest in the LBRF group and lowest in the WELL group (Appendix Table 13). There were also significant negative correlations between age, and SKTEMP and body temperatures for the STDY group (Appendix Table 10). This probably reflects the fact that a majority of the febrile illnesses, such as LBRF, were found or seen in younger, male patients.

The positive and negative correlations between skin temperature and louse levels are difficult to interpret, particularly since the scattergrams for these variables showed no distinct linear relationships. Also, less than half of the STDY group was sampled for SKTEMP due to delays in the receipt of testing equipment.

It has been reported by a number of workers including Nuttall (1919) and Buxton (1947) that lice tend to leave febrile patients. This has been attributed to both the high temperature and increased humidity (Wigglesworth, 1941). It has also been reported that febrile patients may often have large numbers of eggs in their clothing but no lice (Buxton, 1947). Under controlled conditions, Lloyd (1919) found that body lice released on feb-

Figure 27. Excessive number of body louse nits (eggs) found inside the trousers of a volunteer patient.

rile patients tended to migrate to afebrile persons nearby. His results may not be strictly applicable, however, to persons with natural infestations as found in our investigation.

Of the 176 patients in the STDY group, 72 (41%) had body temperatures of > 38.0°C and all were lousy to some degree. This and additional evidence described below suggests that lice do not always leave febrile patients; a condition which is of epidemiological importance.

Estimations of nits in a patient's clothing were not usually made or recorded except in cases where the numbers of eggs appeared significantly out of proportion to the numbers of body lice present. Six patients were observed with relatively low body louse numbers but large numbers of nits. Egg counts in these cases were estimated by counting the number of eggs within a cm^2 clothing area and then roughly estimating the total area involved (Fig. 27). Table 30 shows that while body louse numbers for these patients were relatively large, the total estimate of eggs found were significantly higher. Four of the patients had moderately high fevers and, as a result, it is possible that lice had left these individuals. Alternately, the large egg counts observed could have been due to a long term build-up of eggs on the clothing. As shown in Table 30, the mean number of times clothing was washed and changed by these individuals was quite low. The viability of the eggs observed would have been helpful information but, unfortunately, this was not recorded.

Table 31 shows louse levels and days of illness summarized for all highly febrile patients (rectal temperatures > 39.5°C). For the 12 patients examined, the mean body temperature was 40.0°C and the mean days of illness was 4.9. Total head and body louse counts were relatively

Table 30. Clinical and personal hygiene data for six patients with relatively low body louse levels in comparison to estimates of eggs laid in their clothing.

Patient No.	Rectal Temp. (^{o}C)	Days of Illness	No. Lice	Estimate No. Eggs	Mean Times Clothes Were: Washed/yr	Mean Times Clothes Were: Changed/yr
4	39.4	UNK	175	2500	6	6
5	39.6	UNK	573	5000+	24	1
6	37.6	UNK	240	1500	4	4
9	38.9	UNK	223	1550	52	0
248	37.0	2	56	2000+	0	0
254	39.2	5	240	5000+	12	0
Mean	38.6	-	251	2925+	16.3	1.8

high ($\bar{x}$= 1517.5, GM=389.7). There was no indication that louse distribution in the clothing differed markedly from that found in the other STDY group patients. For four of the subjects, 23-35% of the body lice were located in the underpants even though these individuals had rectal temperatures approaching 40°C or above. Similarly, there were no instances in which egg count estimates appeared to be out of proportion to the number of body lice present.

Table 32 lists 18 patients diagnosed with a febrile illness and having louse levels exceeding 1000. Body temperatures and days of illness for these individuals were relatively high.

Finally, when the clothing was removed from one LBRF patient, two adult lice were observed feeding from his abdominal region. The subject's rectal temperature at the time was 40.0°C.

A number of factors must be considered when interpreting the above data. Body temperatures for those with LBRF may have been recorded at an afebrile interval (and been near normal or below) or at the peak of a febrile period (and been exceptionally high). Skin temperature data would have been useful but was not available for a majority of the patients listed in Tables 30-32. The days of illness were based on the patient's response to questioning and may not have been an accurate estimate of the actual days with fever. Possibly the lice leave the body only at sustained and acutely high temperatures over 40°C; a condition which could not be assessed for the subjects in this study by taking only one rectal temperature reading. Personal hygiene must play an important role, at least for body lice, since the louse numbers assessed on a patient would depend on the frequency with which his clothing was washed and changed prior to and during his illness. In Tables 31 and 32, the mean times clothing was washed and changed was markedly low for all but five of the patients.

While investigating outbreaks of relapsing fever in Rohtak, India, Cragg (1922) observed that every patient examined, febrile or convalescent, was infested with lice. Individuals acutely febrile were found to support few active lice although eggs were present, sometimes in significantly high numbers. Gear *et al.* (1944) studied typhus in the Transkei and found infected lice on several convalescent patients including a child who had been convalescent for nearly two weeks. While studying the adverse affects of lice on human hosts, Jamieson (1888) suggested that lice actually produced fevers in some individuals. He reported that the body temperatures of two patients dropped from 39.4°C and 41.1°C to normal when their lice were removed (cited by Moore and Hirschfelder, 1919).

Actual louse numbers were not given in the above studies, but it is apparent that lice will remain on febrile patients under certain circumstances. In cases of louse-borne disease, this is of epidemiological importance, since body lice remaining on a febrile patient would have a greater chance of becoming infected. The opportunities of spreading the disease would subsequently be increased when the patient returned to his village.

Sweat NaCl

The only significant correlation between sweat NaCl and louse levels was for body lice and sweat Na (SWNa) in the MISC group (Table 25). A larger number of samples might have provided more meaningful results, but only 43 of the STDY group patients could be sampled due to the late receipt of testing equipment.

For the mean values of sweat NaCl measurements, a small significant difference was found between SWNa and sex in the STDY group (Appendix Table 12), but no significant correlations were found between age and either SWNa or SWCl (Appendix Table 10). There were also no significant correlations found between sweat NaCl concentrations, and either SKPH, skin temperature or body temperature. A highly significant and negative correlation was found, however, between SWNa and SWCl in the STDY group (N=43, r=-0.70, P= < 0.001).

Conflicting reports exist in the literature regarding NaCl concentrations in general body sweat as affected by sweating rate, skin temperature, body temperature, metabolic rate, peripheral circulation, sex and age. The complexities of the problem have been discussed by Johnson *et al.* (1944), Robinson and Robinson (1954), Marples (1965) and Dill *et al.* (1966).

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Table 31. Clinical and personal hygiene data for 12 highly febrile patients (rectal temperature > 39.5°C).

Patient No.	Rectal Temp. (°C)	Days of Illness	No. of Body Lice	No. of Head Lice	Total Lice	Mean Times Clothes Were: Washed/yr	Changed/yr
1[a]	40.4	UNK	465	663	1128	12	12
14[a]	40.4	UNK	400	259	659	24	1
55	40.0	10	14	44	58	52	52
66[a]	40.0	3	185	59	244	12	0
84	40.0	4	220	45	265	12	12
366	40.0	7	1	0	1	12	0
22	39.9	5	4900	105	5005	12	0
257	39.9	3	1220	8	1228	6	0
372[a]	39.8	3	3084	247	3331	6	0
378	39.8	5	15	54	65	3	0
5	39.6	UNK	573	14	587	24	1
33	39.6	4	4440	1199	5639	36	52
Arth. Mean	40.0	4.9	1293.1	224.8	1517.5	17.6	10.8
Geo. Mean	-	-	254.7	62.8	389.7	-	-

[a] 23-35% of the lice were found on the underpants.

Table 32. Clinical and personal hygiene data for 18 patients diagnosed with a febrile illness and having louse levels exceeding 1000.

Patient No.	Rectal Temp. (^oC)	Days of Illness	No. of Body Lice	No. of Head Lice	Total Lice	Mean Times Clothes Were: Washed/yr	Changed/yr
37	39.1	4	10700	2167	12867	12	0
249	38.6	3	11200	193	11393	12	0
34	37.0	8	10200	0	10200	4	0
40	38.3	15	7700	78	7778	4	0
36	39.0	14	6941	35	6976	3	0
33	39.6	4	4440	1199	5639	36	52
50	37.4	4	5250	0	5250	6	52
22	39.9	5	4900	105	5005	12	0
75	37.1	6	3880	414	4294	2	2
31	38.0	3	3633	116	3749	24	24
372	39.8	3	3084	247	3331	6	0
53	39.4	4	3000	97	3097	4	0
58	38.2	3	2950	29	2979	4	4
15	37.0	5	2018	543	2561	1	0
57	38.0	3	1181	918	2099	52	52
208	39.0	8	2049	0	2049	2	0
257	39.9	3	1220	8	1228	6	0
367	39.4	8	1000	45	1045	12	0
Mean	38.6	5.7	4741.4	344.1	5085.6	11.2	10.3

Comparative studies of individuals with different sweat rates and louse infestations have received little attention. Nuttall (1917) cites the work of Hase (1915b) who reported finding no differences in louse attack rates between freely perspiring men and others. In laboratory studies, lice have been observed to exhibit avoidance behavior towards moist surfaces and high humidity (Wigglesworth, 1941). As men exercise and perspire, body lice move away from the damp, sweaty areas of the body surface (MacLeod and Craufurd-Benson, 1941; Busvine, 1944). We observed in some young Ethiopian boys with large head louse populations that after vigorous play the lice moved to the outer hair shafts, thus giving the head a rather peculiar appearance. The transmission of lice from one person to another must also be enhanced under such conditions.

Skin Flora

Table 33 shows the prevalence of skin surface bacterial flora isolated from three body regions of 111 patients. Frequency distributions of body lice calculated for individuals with and without each of the 24 different organisms isolated were not significantly different by chi-square analysis (sample sizes smaller than 11 not included).

Bacterial flora were isolated from all but three of the 111 subjects sampled. *Staphylococcus epidermidis* was the organism most frequently isolated followed by *Bacillus* sp., *Streptococcus viridans*, *Enterobacter* sp. and *Staphylococcus aureus* (Table 33). These five organisms accounted for over 72% of the total of 330 isolations.

It has been suggested that research on louse pathogens has been inadequate and that bacteria pathogenic to lice, but not to humans, might have some application to the biological control of lice. Currently, however, bacteria known to be pathogenic to lice are also pathogenic to man (Jenkins, 1973).

In a list of 20 species of bacteria studied in lice, Jenkins (1973) stated that eight were considered to be pathogenic to human lice including *Escherichia coli* and *Proteus vulgaris*.

Krynski (1973) found that the direct passage of *S. aureus* many times in lice increased its virulence for the insects. He also reported that *Pseudomonas* and *Aeromonas* species appeared to be more pathogenic for lice than Enterobacteriaceae. Certain strains of *Staphylococcus* have been reported to be highly pathogenic for human lice (Gaon, 1973).

Proteus, *E. coli*, *Pseudomonas* and *Aeromonas* are all Gram-negative organisms considered to be decidedly scarce on the skin and to have highly restricted intertrigenous habitats (Kligman, 1965). The prevalence of these organisms on the subjects in this study was low and reduced the possibility of finding any association with louse density.

S. aureus, a frequent inhabitant of human skin, was isolated from 25% of the individuals sampled. A comparison of body louse levels for individuals with and without the organism was not found to be significant ($X^2=8.37$, $P=0.593$).

The microbial flora inhabiting normal skin and those factors which may regulate the skin flora (pH, temperature, hydration, and others) are extensively reviewed by Marples (1965), and Maibach and Hildick-Smith (1965). The results found in this study have not been reported previously and provide a guide for future investigations.

Dermatitis

Nelson *et al.* (1977) discussed the "immuno-allergic" responses of animal hosts to ectoparasites and stated that the most commonly reported clinical manifestation in man was dermatitis. The authors also discussed the sequence of time of skin reactivity in hosts exposed to repeated insect feeding. The sequence appears to follow a general pattern: Stage I, no reaction; Stage II, delayed reaction; Stage III, immediate plus delayed reaction; Stage IV, immediate reaction; Stage V, no reaction. These reactions are not always clearly defined, may require years to complete and the mechanisms are not understood. In their review of reports on dermatitis in man caused by ectoparasites, the authors believed that in one in-

Table 33. Bacterial flora isolated from three body regions of 111 volunteer patients.

Organism	Isolations N	%	% Total
Staphylococcus epidermidis	84	75.7	25.5
Bacillus sp.	64	57.7	19.4
Streptococcus viridans	34	30.6	10.3
Enterobacter sp.	29	26.1	8.8
Staphylococcus aureus	28	25.2	8.5
Escherichia coli	12	10.8	3.6
Pseudomonas sp.	12	10.8	3.6
B – hemolytic streptococcus	11	9.9	3.3
Enterococcus sp.	11	9.9	3.3
Corynebacterium sp.	8	7.2	2.4
Diphtheriod sp.	7	6.3	2.1
Moraxella osloensis	7	6.3	2.1
Alcaligenes sp.	4	3.6	1.2
Proteus mirabilis	4	3.6	1.2
Neisseria catarrhalis	3	2.7	0.9
Aeromonas salmonella	2	1.8	0.6
Klebsiella pneumoniae	2	1.8	0.6
Listeria monocytogenes	2	1.8	0.6
Aerobacter sp.	1	0.9	0.3
Citrobacter sp.	1	0.9	0.3
Enterobacter agglomerans	1	0.9	0.3
Herellea sp.	1	0.9	0.3
Pneumococcus sp.	1	0.9	0.3
Serratia sp.	1	0.9	0.3

stance at least the first three stages of the five-stage sequence occurred in human volunteers exposed to human louse bites.

Clinical manifestations of louse bites include urticarial eruptions and pruritus which in severe cases may result in secondary eczema or impetigo-like lesions from scratching. In chronic cases, the skin may become thickened, dry or scaly and a melanoderma or brownish skin pigmentation may eventually develop; a condition which has been termed "Vagabond's disease" or morbus errorum (Nuttall, 1917; Frazier, 1972). Morely (1977) believed that the so-called Vagabond's disease was due to a combination of a lack of cleanliness, malnutrition and associated pediculosis.

Eleven patients in the present study were assessed as having some kind and degree of dermatitis. Six of the patients were diagnosed with LBRF and their petechial rash was typical of that associated with the disease (Bryceson *et al.*, 1970). A rash attributed to secondary syphilis was observed on three other patients. Finally, lesions found on two subjects were attributed to an infestation of scabies in one case and to leprosy in the other. The density of body lice on the 11 patients was not remarkable except for one patient with LBRF (906 lice).

None of the individuals in the study with comparatively high louse burdens were observed to have an associated dermatitis. This included patient No. 49 whose body louse count exceeded 21,500 lice. His skin, upon examination only, was considered normal by a consulting dermatologist.

It could not be readily determined in this study whether those patients heavily infested with body lice were in a Stage I of non-reactivity or Stage V of desensitization. In general, however, our results agree with those of Cragg (1922) who reported the following observation during his louse-borne relapsing fever studies in India:

> None of the effects which are said to follow long continued infestation were observed among these people. Even heavily infested individuals were found to have a smooth and healthy skin, with none of the roughening and pigmentation which has been described as resulting from louse bites. The people do not, in fact, appear to be incommoded by their parasites, or to notice their presence.

Hair Variables

Tables 34 and 35 show the frequency distributions of hair weight and hair length as related to head louse levels. While not significant by ANOVA, the trend of the mean louse levels suggests that as hair weight and length increase, the number of head lice increases. This trend is most clearly shown for hair weight in males by Duncan's multiple range test. Weak but significant positive correlations were found between head louse levels in males and both hair weight and length. The scattergrams for these variables also showed a fair linear trend. The mean number of head lice was greater in females than males but not significantly different by ANOVA ($F=3.56$, $P=0.62$). There were no distinct correlations between head lice in females and the hair variables.

Correlation coefficients between hair weight and length, and either patient age or tribe were low and not significant. As shown below, however, there was a significant difference beween the hair variables and sex as revealed by an ANOVA:

Sex	Hair Weight (g)	Hair Length (cm)
Male	18.27 ± 8.28 (N=108)	3.04 ± 1.56 (N=106)
Female	41.63 ± 27.87 (N=11)	9.77 ± 5.23 (N=11)
	$F=42.17(1,117) P<0.001$	$F=98.17(1,115) P<0.001$

Hocking (1957) reported that claw size in lice was related to hair diameter of the host. The oval cross-sectional shape of hair in Guyanese children was believed to be less favorable to head lice than the round shape of the hair in East Indian children (Ashcroft, 1969). Lang (1975) found no significant differences in the preference for egg deposition by head lice in hair samples taken from Caucasians, Mexican-Americans and Yaqui Indians in Arizona. We found no significant association between head louse levels and hair diameter of eight different tribes. Also, hair

Table 34. Geometric mean (GM) levels of head lice for different hair weight distributions in 119 male and female patients of the STDY group.

Hair Crop Weight (g)	Males			Females		
	N	GM	SD	N	GM	SD
0.0- 9.9	8	12.4a *	8.3	0	-	-
10.0-19.9	63	24.7ab	5.8	3	88.9a	3.1
20.0-29.9	30	46.8ab	7.4	2	52.4a	1.6
30.0-39.9+	7	112.0b	12.3	6	125.3a	3.7
Total	108	31.0	6.9	11	97.4	3.0
ANOVA		2.31 (P=0.081)			0.40 (P=0.680)	
Pearson's r		0.29 (P=0.001)			-0.23 (P=0.248)	

*Means followed by different letters are significantly different at the 5% level (Duncan's multiple range test).

Table 35. Geometric mean (GM) levels of head lice for different hair length distributions in 117 male and female patients of the STDY group.

Hair Crop Length (cm)	Males			Females		
	N	GM	SD	N	GM	SD
0.0-1.9	23	19.4a*	4.8	-	-	-
2.0-3.9	60	26.4a	6.9	-	-	-
4.0-5.9	16	64.8a	8.4	3	78.0a	3.4
6.0-7.9	7	109.4a	4.2	8	105.9a	3.2
Total	106	31.1	6.7	11	97.4	3.0
ANOVA		2.41 (P=0.071)			0.15 (P=0.711)	
Pearson's r		0.26 (P<0.004)			-0.12 (P<0.358)	

*Means followed by different letters are significantly different at the 5% level (Duncan's multiple range test).

diameter was not significantly correlated with either patient age or sex nor with head louse levels in either male or female patients.

In past studies on the relationship between hair length and lousiness, only those of Buxton (1936, 1938, 1940b) involved shaving the head and using hair weight as a measure of hair length (which Buxton considered to be the best estimate of hair length). Slonka (1975) believed that using hair weight as a measure of hair length might confuse any results obtained because the former may be affected by such factors as individual variations in hair density, hair shaft diameter, degree of hair coarseness and scalp size. In their studies, Slonka *et al.* (1976, 1977) determined hair length using three categories (short, medium, long) based on the length of hair in relation to the subject's ears and location of the shirt collar. Louse counts were assessed directly on the head using applicator sticks to part the hair while searching for the lice.

Under the conditions of this study, however, shaving the head was found the most acceptable means of obtaining accurate louse counts. The use of hair weight and hair length appeared to be equally useful in this study for comparison to louse levels. Correlation coefficients determined between hair weight and length were, in fact, highly significant for males ($N=106$, $r=0.68$, $P<0.001$) and females ($N=11$, $r=0.87$, $P<0.001$). Hair weight was, therefore, a fairly good estimate of hair length especially in females whose hair was generally of uniform length.

Studies on louse prevalence as related to hair length have involved conflicting reports in the literature. Buxton studied over 3,700 crops of hair taken from individuals in hospitals and jails mostly in Africa and Asia (Buxton, 1936, 1938, 1940b). He found a strong positive correlation between hair weight and infestation in hair crops in some locations but no relation between the two in other locations. Buxton later concluded, however, that hair weight was the major factor influencing the distribution of head lice (Buxton, 1941c).

It has been suggested by a number of authors that the higher prevalence of head lice in females than males could be attributed to the longer hair length in the former (Mellanby, 1942a; Hopper, 1971; Maguire and McNally, 1972; Lang, 1975). Roy and Ghosh (1944), however, reported that short-haired individuals were more heavily infested than long-haired ones in their study. They did not define hair length and did not report age ranges for the 67 subjects examined. There were no males included in their "long hair" category.

Coates (1971) suggested that recent changes in hair styles towards longer hair in males has not increased their liability to infestations. Slonka *et al.* (1976, 1977), however, did not find any relationship between hair length and louse incidence in either males or females. Also, their studies were the only ones which defined hair length.

Maunder (1977) suggested that hair length had little effect on louse transmission. He believed that hair length of about 8.5 mm was a minimum threshold value, below which lice could not maintain a mechanical hold on the hair shafts, and temperatures optimal for the insect's survival would not be maintained. Hair longer than this minimum value would probably not affect the louse's "daily life."

None of the above studies reported statistics for mean levels of lice encountered as related to either hair weight or hair length. The reason for this may have been because only small infestations were found. In our study, only 13 of the 119 subjects examined were found free of head lice. Prevalence rates, therefore, were not considered.

The role hair length may play in determining whether an individual becomes infested or not is of interest. It is equally important to consider the role it may also play as to the density of the infestation which develops. Presumably, longer hair length would make lice less visible to the host, at least until populations reach a certain level.

CULTURAL ATTITUDES, BELIEFS AND PRACTICES AFFECTING PEDICULOSIS

Discussed below are examples of superstitions and beliefs the people had concerning lice and louse-borne diseases, the methods they used to eliminate head and body lice, and the opportunities observed for the transfer of lice during their daily activities.

Origin of Lice

It was commonly believed that lice originated by spontaneous generation from dirt and sweat. As one man expressed it: "If I keep clean, lice will not be formed." Similar beliefs have been described in the writings of certain medieval and renaissance authors (Busvine, 1976) and in the Talmud (Harpaz, 1973).

Illness is frequently attributed to supernatural causes (Pankhurst, 1965) and this may include pediculosis. For example, it was reported by one Ethiopian that: "When people have the evil eye power, they can look at a beautiful person and cause them to have lice." In another instance, a man stated: "God throws lice, fleas and bed bugs on us as punishment."

A few individuals maintained that if a person went bareheaded in the rain, head louse nits would be formed in his hair.

Pediculosis Beliefs

Many of the subjects questioned believed lice to be beneficial rather than harmful. Having lice, for example, was considered to be a sign of intelligence or of future wealth. Typical comments included: "If a child has many lice he will be rich in adulthood," "I wanted lice as a child so I would be wealthy when I grew up," and "A man who has many lice will be lucky and rich."

Although priests were notably lousy as a group, they often refused to even sell their lice to NAMRU-5 personnel for the purpose of conducting insecticide resistance studies. Most believed that an excessive louse burden was favorable for "getting into heaven" or as one elderly priest stated: "Injera (the staple food) is given to me by God and, therefore, I give it to the lice through my body."

These beliefs are not unique to Ethiopia. In medieval times, holy men tolerated their louse burdens as a demonstration of their humility and self-denial (Clausen, 1954). Shipley (1915) noted that the "poorer folk" in England associated lice with productivity and that their removal would cause the host to become barren or sterile. Sobel (1913) stated that it was not uncommon to find individuals in New York who believed that lice were a sign of health and strength. In a personal experience during World War II, Busvine (1976) observed that after the heads of refugee children had been deloused, one mother intentionally reinfested her child in the belief that "lice were beneficial to health and vigour."

Lice were not associated with disease by most of the individuals questioned, and it has been reported elsewhere that many Ethiopians believe typhus to be transmitted by the breath of an infected person (Levine, 1972).

Louse Toxicants

A number of different commercial and locally prepared compounds are employed as louse toxicants for the control of the head and body lice. Insecticides, however, are not commonly used. Of the 5,483 persons questioned during the field surveys, only 1,061 (19%) reported using some kind of insecticide for either personal or household purposes. Insecticides could be purchased in local markets or pharmacies and, although European commercial preparations were available, the cheaper, locally packaged ones were more popular. Malathion emulsifiable concentrate could be readily purchased in discarded vaccine vials while DDT powder was available in small, paper packets (Fig. 28).

Resistance in body lice to malathion has been reported from Ethiopia (Sholdt *et al.*, 1976) and unpublished studies by NAMRU-5 also report DDT and lindane resistance. This is of epidemiological importance since relatively few insecticides have been approved for use against human lice and an increased reliance has been placed on malathion for the control of louse populations resistant to DDT and lindane.

Plants or plant extracts are used by some against lice. At'efaris or Jimson weed (*Datura stramonium*) is, for example, used in two different forms to control head lice. The juice extract is applied directly to the hair, or the plant is dried, ground and mixed with butter or salt before application. Mature flowers of the Maskal daisy (*Coreopsis borianiana*) are used in the bedding to repel lice and fleas.

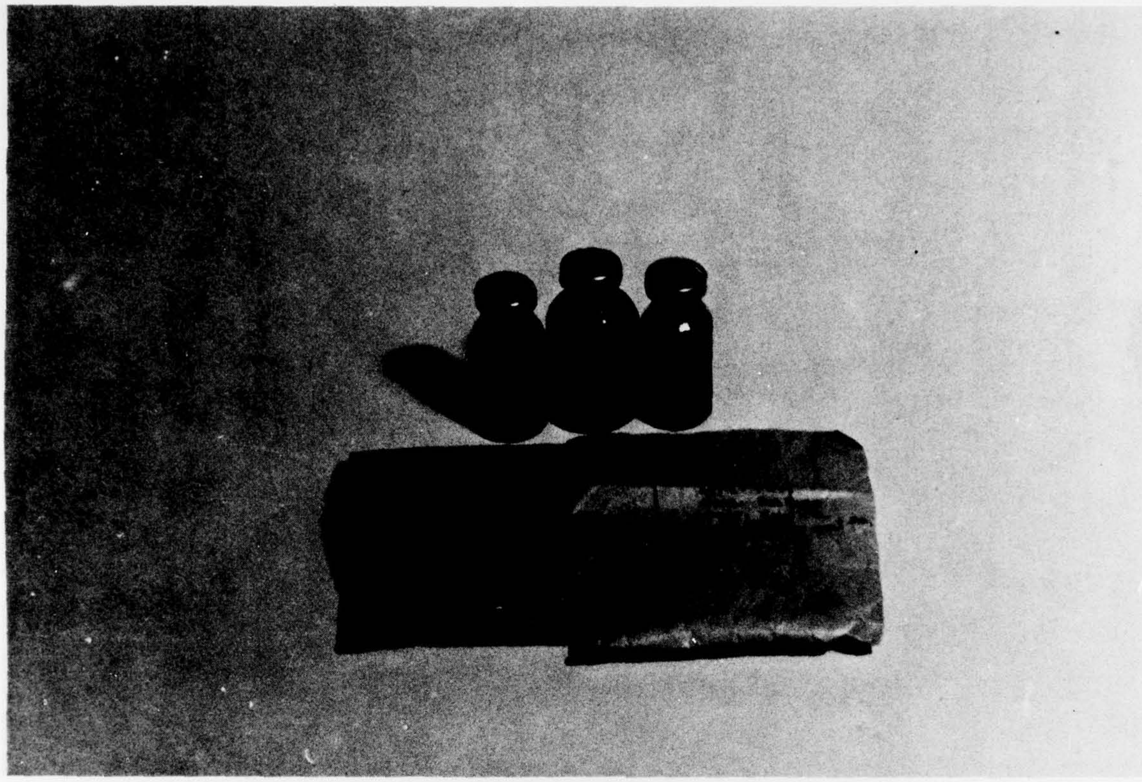

Figure 28. Locally prepared vaccine vials of malathion and packets of DDT insecticide sold in the markets and pharmacies of Ethiopia.

Certain semi-nomadic Galla and Tigre tribesmen in the northern provinces of Ethiopia treat their hair with large quantities of butter which eventually soaks into their clothing. This is not objectionable because it is believed that white, clean and "unbuttered" clothes attract lice. Buxton (1947) noted that in remote regions of Poland, Carpathians smeared butter on their clothing to control body lice.

Delousing Operations

A number of self-grooming and other delousing operations were observed during the investigation. Interviews of the hospital patients provided the most extensive information on these operations. Of 151 persons questioned, a majority (50%) stated that they eliminated lice by searching for them through the hair (Fig. 29) or along the seams of their clothing (Fig. 30). Any lice found were usually crushed between the fingernails (a practice which left a visible exudate on the nails of some heavily infested persons) or simply discarded. Actual eating of lice was not observed or reported although one man said he cracked lice between his teeth as a form of "revenge".

Clothes washing was specifically mentioned by some (27%) as a method of louse control while others (18%) indicated that they put their clothes out in the sun to kill lice. The remainder (5%) used a variety of methods which included pressing the seams of clothing with a hot iron, washing the clothes in salt water or treating them with insecticide.

Two novel means of louse elimination included the procedure of one individual who said he periodically placed his clothes in the sun which caused the lice to become active. Dirt was then thrown on the garments and, after a few minutes, shaken off. The lice were removed clinging to the particles of dirt.

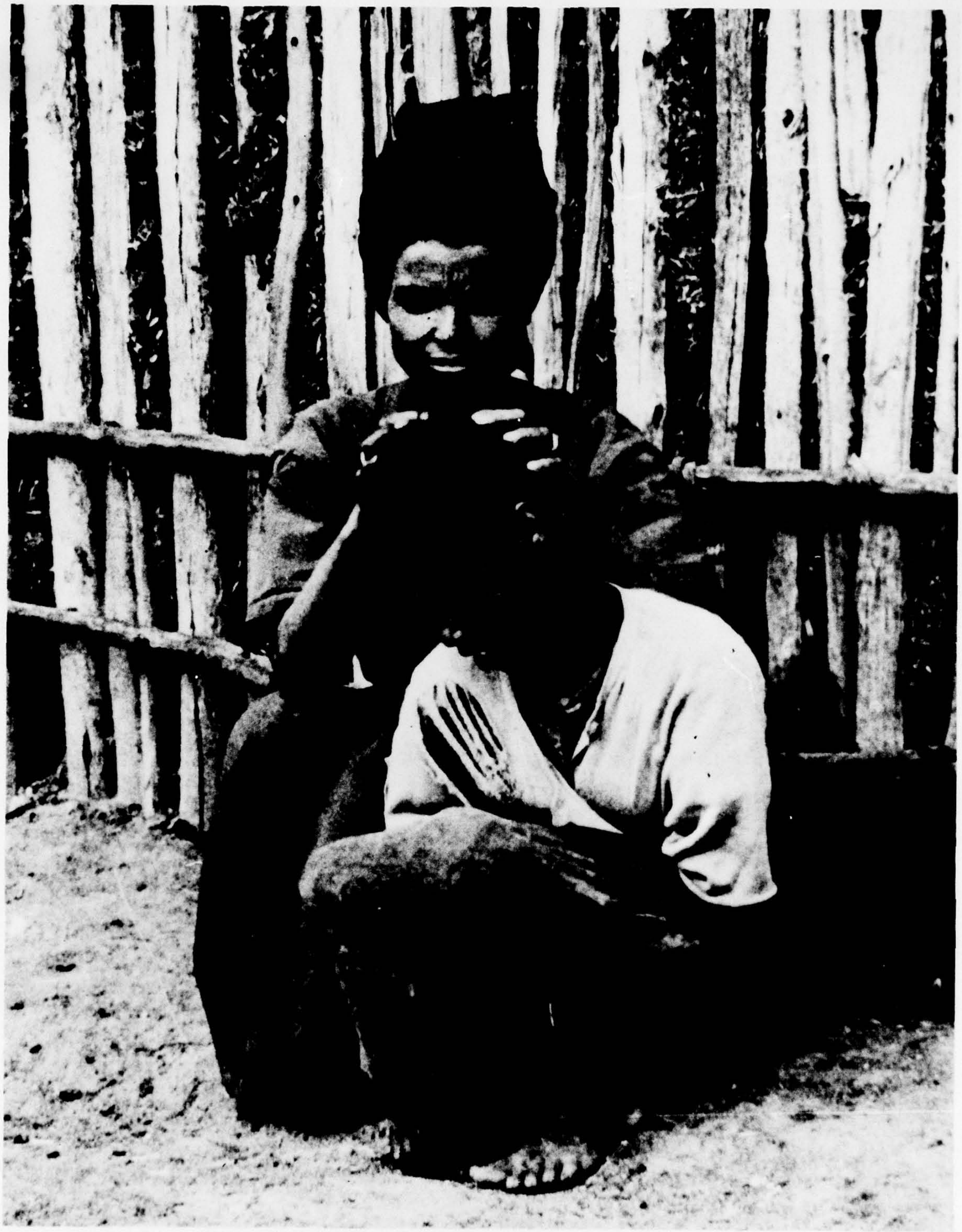

Figure 29. An Amhara mother searching for head lice on her young child.

Figure 30. An elderly beggar searching for body lice in the seams of his shamma.

Figure 31. Plaster of Paris cast on a male patient with leprosy which was found heavily infested with body lice.

In the other case, an Ethiopian stated that he threaded string through the teeth of his comb prior to combing his hair. The lice attached themselves to the string and were then easily removed.

In an unusual infestation, an excessive number of body lice were found inside the plaster of Paris cast of a male patient with leprosy (Fig. 31). The patient stated that he periodically exposed the cast to direct sunlight until the increased temperature drove the lice outside where they could be easily killed by hand.

Louse Transfer

The opportunities for the spread of human lice in Ethiopia appear innumerable. The people are crowded closely together on market days in the towns and villages (Fig. 32) and in the buses which travel the main highways throughout the country. Under such circumstances, lice and louse-borne diseases can be easily transferred from one person or family to another, and from town to town. As previously discussed, dwelling places such as churches, hotels and prisons are often overcrowded and offer ample opportunity for the dissemination of lice. This is also true during certain Ethiopian ceremonies. At a traditional Ethiopian wedding, the guests may be pressed together for several hours beneath a large tent while they eat and drink. Similarly, during funerals the mourners may gather inside a tent for 3-5 days. At night, they commonly share blankets and bedding.

The interpersonal contact between Ethiopians has been discussed by Levine (1972) who stated:

> The Amhara enjoy bodily contact. Members of the same sex customarily hold one another's hands for long periods while conversing, or embrace

Figure 32. Typical market place in a rural location of Ethiopia.

one another in casual fellowship. Crowds of commoners cheerfully huddle close to one another on the floor through the night when they have assembled for some social function and cannot return home the same day. Relatives and companions of the same sex incline to sleep in one another's arms, at least in the chillier altitudes. Both their style of dress and their manner of eating give the Amhara a ready way to express this comradely feeling. Their untailored cotton or wool cloth easily adapts itself to being shared. Except perhaps for individuals of high social status, the typical Amhara is ready to use his toga as a blanket-wrap for both himself and another whom he may scarcely know.

A lack of understanding of a population's customs, beliefs and living habits may cause louse eradication programs to fail (Makara, 1973). The above observations, therefore, are not only of some interest but are epidemiologically important, for they reveal the extent to which health education will be necessary in any future public health efforts to control lice and louse-borne diseases in Ethiopia.

SUMMARY AND CONCLUSIONS

A descriptive epidemiological investigation of human pediculosis was conducted in Ethiopia under a medical entomology research program of the Naval Medical Research Unit No. Five. The investigation was conducted during the period of January 1974 to July 1976 and involved field and hospital observational studies of 5,878 individuals.

NATIONAL SURVEY

In a survey encompassing many of the ecological areas of Ethiopia, the prevalence and density of head and body lice were determined for 3,133 persons in 49 towns and villages, and 23 prisons.

Overall, the percentage prevalence and density of body lice were higher on prisoners (75.5%, GM=12.2) than on non-prisoners (59.1%, GM=5.0). Head louse infestations, however, were higher on non-prisoners (24.4%, GM=0.6) than on prisoners (11.0%, GM=0.2). Significant correlations were found between the proportion of non-prisoners infested and the intensity of their infestations for body lice (r=0.64) and head lice (r=0.81). Similar results were obtained for prisoners.

Individuals living at increased elevations generally had greater prevalence and densities of body lice than those living at lower altitudes. A similar association was not found for head louse infestations.

Body louse prevalence was significantly correlated with the frequency that clothes were washed by non-prisoners (r=-0.58) and prisoners (r=-0.57).

Observations on relapsing fever outbreaks in a hot, tropical lowland region of southwestern Ethiopia, suggest that the disease was primarily louse-borne. In this area, body louse prevalence was relatively high but densities were low; lice and nits being found in small numbers on beads, necklaces, bedding and clothing owned by the nearly nude population. Transmission of the disease was believed to have been sustained by certain native customs involving intimate contact and casual migrations. These results differ from most past observations which associated louse-borne relapsing fever with cold, highland climates and under conditions of a general abundance of lice on more heavily-clothed persons.

LONGITUDINAL STUDY

A total of 2,359 persons were examined for head and body lice during a 24 month period in Addis Ababa. The overall percentage prevalence and density of body lice (60.9%, GM=9.9) and head lice (26.2%, GM=1.1) were somewhat higher than those for the town and village populations.

Significant correlations were found between body louse prevalence and precipitation (r=0.40) and relative humidity (r=0.47). There was no further evidence suggesting seasonal fluctuations in louse infestations.

The frequency that clothes were washed each month was significantly correlated with body louse prevalence (r=-0.67) and density (r=-0.71). A similar association was found between body louse infestations and the frequency that clothes were changed.

Monthly louse-borne relapsing fever cases recorded from a free-care clinic in Addis Ababa showed significant correlations with relative humidity (r=0.61), precipitation (r=0.64) and temperature range (r=-0.60). The increased

number of louse-borne relapsing fever cases during the relative wet months of March through September compared to the dry months of October through February coincided to some degree with a period when a larger number of persons were infested with body lice (r=0.52). No significant association was found between louse-borne relapsing fever occurrence and body louse densities.

PERSONAL AND SOCIOECONOMIC VARIABLES

Age

The proportion of persons with body lice increased significantly with age. For males, this increase occurred after age nine and continued at a high level thereafter. For females, the increase was more gradual with a peak occurring at age 60 and over. Body louse density also increased with age but this was not significant.

Head louse prevalence showed a significant decrease with age. The proportion of males and females infested with head lice was closely correlated for the different age groups; the prevalence rates being highest in the 10-19 age group. Head louse density showed a similar decrease with age but this was not significant.

Sex

Males had significantly higher body louse infestations than females; a difference which may be attributed to such factors as occupation, marital status and personal hygiene. Head louse infestations did not differ significantly between males and females.

Ethnic Group

The prevalence and density of human lice were found to differ significantly between some of the 25 ethnic groups sampled during the study. There was not sufficient evidence available, however, to associate these differences with variations in tribal attitudes, customs regarding hair dressing, washing or other personal grooming and hygiene practices.

Religion

Differences found in body louse prevalence and density between the religious groups examined were influenced more by variations in personal hygiene than by any religious factors.

Education Level

The prevalence and density of head and body lice decreased with increased education.

Marital Status

Associations between marital status and pediculosis were slight except in certain instances; married persons had lower infestations of head and body lice while divorced persons had higher infestations.

Occupation

Differences in pediculosis between 19 occupational groups sampled were usually greater for body lice than head lice. High risk groups included beggars, farmers, laborers, priests and unemployed persons. Low risk groups included clerks, teachers, dressers, truck drivers, police and military personnel.

Length of Residence

Migrants had higher attack rates and levels of body lice than settled persons. No significant differences were found between the two groups in head louse infestations. The personal hygiene habits of settled persons were significantly better than those of migrants.

Urban-Rural Residence

Residents in rural areas showed higher prevalence and levels of head and body lice compared to persons residing in more urban areas. For body lice, this difference was influenced by personal hygiene practices.

Dwelling Place

Individuals living in churches, hotels and porches had notably higher head and body louse infestations compared to those living in modern homes and mud shacks.

Crowding

A majority (88%) of the subjects examined shared a room with 1-10 persons at night. There was no evidence found, however, that increased crowding within dwelling places had a significant influence on head or body louse infestations.

Personal Hygiene

Of the host factors considered, the frequency clothes were washed and changed clearly had the most significant influence on body louse infestations. The prevalence and density of body lice decreased dramatically when clothes were washed or changed once a week. Because water sources were generally inadequate or not readily available, only one-third of the population examined was able to change or launder their clothes at this threshold level.

The practice of laundering clothes by hand in cold water and drying them in the sun was considered to be inefficient for the complete control of body lice.

SIZE AND DISTRIBUTION OF LOUSE POPULATIONS

A majority (84%) of the non-prisoners infested with body lice had from 1-100 lice while for head lice, a majority (78%) had from 1-25 lice. The mode in both instances was between 1-12 lice. Similar results were obtained for prisoners.

Males were more frequently found with heavy louse infestations than were females. The highest louse counts recorded were over 21,500 body lice on one male patient and 2,167 head lice on another.

The proportion of individuals with simultaneous infestations of head and body lice were found to decrease somewhat with age and to be nearly equal in males and females. The highest double infestation recorded was on a male patient with 10,777 body lice and 2,167 head lice. The highest for a female was 1,181 body lice and 918 head lice.

Crab lice were rarely found on individuals in this investigation; a phenomenon associated with the widespread practice by both sexes of regularly shaving the pubis.

HOSPITAL STUDY

A cross-sectional medical study involving over 50 different clinical tests and measurements was performed on 386 volunteer patients in Addis Ababa. The objective was to determine if associations existed between louse levels and different hematological, biochemical and anthropometric variables, intestinal parasites, skin pH and temperature, sweat NaCl, skin microflora, and hair length and weight. Conclusive evidence that these variables were closely associated with pediculosis was generally lacking, although weak correlations were found in certain instances. This included a limited association between ABO blood groups; the density of body lice on individuals with blood group AB being nearly seven times that of persons with blood group O.

Evidence was obtained which suggests that body lice will remain on febrile patients. In cases of louse-borne diseases, this may increase the opportunities for lice to become infected and enhance the spread of the disease within a community.

As a clinical manifestation of louse bites, dermatitis was not found to be associated with body louse populations even on individuals with comparatively high parasite burdens. It remains to be determined if this phenomenon reflects a condition of non-reactivity or desensitization of the host.

HEALTH EDUCATION

Certain cultural attitudes, beliefs and practices enhance the spread and maintenance of lousiness in Ethiopia. Health education will be necessary, therefore, in any future public health efforts to control lice and louse-borne diseases in the country.

APPENDIX

Appendix Table 1. Specific biochemical and hematological laboratory tests conducted on volunteer patients in Addis Ababa, Ethiopia.

Hematology

Erythrocyte Sedimentation Rate--Wintrobe procedure

Hemoglobin--Cyanmethemoglobin reaction read in Fischer Hemophotometer

Hematocrit--Spun in centrifuge at 5000 G's for 5 minutes

Reticulocyte Count--New methylene blue stain

White Blood Cell and Differential Count--Wright's stain

Platelets--RBC's destroyed with Ammonium Oxalate; read under phase contrast light

Blood Group and Type--Standard blood bank slide method using Anti-A, Anti-B, and Anti-D

Prothrombin Time, Partial Thromboplastin Time--Fibrometer

Red Blood Cell Count--Neubaur Hemocytometer

Urinalysis

pH--Ames Bililabstix

Specific Gravity--American Optical Refractometer

Glucose--Ames Bililabstix

Protein--Ames Bililabstix

WBC--High power field microscopy

Blood Chemistry

Postprandial Blood Sugar--O-Toluidine reaction

Blood Urea Nitrogen--Berthelot reaction

Creatinine--Jaffee-Folin reaction using Picric acid

Alkaline Phosphatase--Bessey-Lowry reaction using Sigma Kit

Serum Glutamic Oxaloacetic Transaminase--Sigma Kit

Serum Glutamic Pyruvic Transaminase--Sigma Kit

Appendix Table 1. Continued.

Blood Chemistry (Continued)

Bilirubin (Total and Direct)--Evelyn-Malloy reaction

Cholesterol--OMNI-Tech Kit using Lieberman-Burchard color reaction

Total Protein--American Optical Refractometer

Sodium--Coleman Flame Photometer

Chloride--Beckman Chloridometer

Potassium--Coleman Flame Photometer

CO_2--Measured as HCO_3 on an Oxford Titrator

Serum Protein Electrophoresis--Beckman microzone with Millipore cellulose acetate membranes

Calcium--EDTA titration micromethod

Phosphorus--Molybdate reaction; read on spectrophotometer

Appendix Table 2. Selected socioeconomic and personal hygiene data for 2435 persons from 49 towns and villages in Ethiopia.

Town	No. in Sample	Median Age	Sex M/F	Predominant (in sample) Ethnic Group	Religion	$\bar{X}(\pm SD)$ Times Clothes Washed/Year
Abol	29	20(3-70)[a]	16/13	Anuak	Pagan	22.5(8.5)
Addis Alem	110	16(<1-79)	52/58	Mixed[b]	Coptic	39.1(20.6)
Anger Guten	113	20(5-45)	93/20	Galla	Coptic	34.6(5.6)
Arba Minch	89	19(<1-47)	59/30	Mixed	Coptic	31.8(18.5)
Ariet	23	15(2-60)	17/6	Anuak	Pagan	11.3(1.9)
Aseita	69	27(<1-65)	50/19	Amhara, Afar	Muslim	65.6(48.0)
Asela	33	4(<1-47)	17/16	Mixed	Coptic	73.2(41.8)
Asmara	36	15(8-50)	29/7	Tigre	Coptic	24.0(0.0)
Asosa	73	16(1-67)	44/29	Berta	Muslim	28.1(20.4)
Awo	21	25(5-65)	4/17	Anuak	Pagan	7.6(4.9)
Axum	89	10(1-70)	64/25	Tigre	Coptic	29.2(20.4)
Begi	69	13(8-50)	52/17	Galla	Coptic	26.0(14.9)
Bonga	74	30(1-68)	39/35	Kaffa	Coptic	28.5(20.2)
Bulcha Forest	29	38(4-70)	20/9	Guji	Pagan	16.2(21.0)
Chida	26	16(4-40)	24/2	Kullo	Coptic	26.9(22.3)
Debre Markos	79	18(<1-78)	64/15	Amhara	Coptic	34.9(41.3)
Debre Zeit	94	20(<1-73)	24/70	Mixed	Coptic	44.4(15.0)
Dembidolo	80	30(<1-90)	47/33	Galla	Coptic	21.5(17.6)
Didessa	194	21(2-80)	141/53	Galla	Coptic	14.6(18.9)
Dire Dawa	50	27(5-65)	34/16	Amhara	Coptic	31.5(21.3)
Dolo	30	13(3-50)	22/8	Somali	Muslim	77.5(33.3)
El Kere	29	35(9-73)	25/4	Arussi	Muslim	44.3(35.6)
Gambela	72	22(<1-60)	30/42	Anuak	Pagan	44.8(38.6)
Gelemso	4	35(32-45)	4/0	Galla	Muslim	2.0(0.0)
Gilo	22	14(2-45)	13/9	Anuak	Protestant	20.2(11.5)
Gok	21	12(1-60)	10/11	Anuak	Pagan	22.5(15.5)
Gondar	66	24(3-73)	58/8	Amhara	Coptic	23.3(25.0)

Appendix Table 2. Continued.

Town	No. in Sample	Median Age	Sex M/F	Predominant (in sample) Ethnic Group	Predominant (in sample) Religion	$\overline{X}(\pm SD)$ Times Clothes Washed/Year
Gore	95	25(<1-75)	47/48	Galla	Coptic	36.8(29.1)
Harar	49	26(17-70)	35/14	Mixed	Coptic, Muslim	33.8(29.3)
Humera	13	40(18-65)	12/1	Tigre	Muslim	4.9(14.5)
Jijiga	46	30(2-60)	34/12	Somali	Muslim	34.8(34.0)
Jikau	31	27(3-50)	23/8	Nuer	Pagan	15.8(13.0)
Koka	31	15(6-60)	31/0	Galla	Coptic	14.5(9.3)
Lalibela	65	18(1-70)	46/19	Amhara	Coptic	12.4(13.8)
Lemi	18	25(10-65)	16/2	Amhara	Coptic	9.3(4.0)
Leper Colony	28	29(15-50)	16/12	Amhara	Coptic	18.3(20.8)
Makale	73	15(<1-70)	35/38	Tigre	Coptic	12.2(19.2)
Makane Selam	30	35(10-75)	14/16	Amhara	Coptic	23.3(16.7)
Massawa	6	30(20-35)	4/2	Tigre	Coptic	4.0(0.0)
Menagesha	3	19(16-27)	3/0	Amhara	Coptic	20.0(6.9)
Menora	26	16(7-60)	21/5	Konta	Coptic	21.1(21.4)
Mizan Teferi	30	22(<1-40)	14/16	Gimira	Coptic	24.5(19.3)
Mota	44	15(6-55)	37/7	Amhara	Coptic	13.9(15.5)
Sheik Hussein	31	15(9-70)	30/1	Galla	Muslim	14.6(8.2)
Tailut	19	45(23-75)	17/2	Nuer	Pagan	12.0(0.0)
Tepi	68	27(4-55)	50/18	Galla	Coptic	32.5(19.8)
Waca	65	22(<1-65)	38/27	Kullo	Coptic	24.7(17.2)
Wollo Ferda	10	11(6-25)	10/0	Amhara	Coptic	12.0(0.0)
Yirga Alem	30	15(7-50)	21/9	Sidamo	Muslim	19.3(18.8)
Total	2435	20(<1-90)	1606/829	-	-	28.1(26.8)

[a] Range in parenthesis

[b] Primarily Amhara and Galla

Appendix Table 3. Selected socioeconomic and personal hygiene data for 698 prisoners from 23 towns in Ethiopia.

Prison Location (Town)	No. in Sample	Median Age	Sex M/F	Predominant (in sample) Ethnic Group	Relgion	$\overline{X}(\pm SD)$ Times Clothes Washed/Year
Arba Minch	40	55(20-95)[a]	40/0	Mixed[b]	Coptic	16.4(13.4)
Asela	27	25(14-70)	27/0	Mixed	Coptic	19.6(20.8)
Asmara	59	19(10-99)	48/11	Tigre	Coptic	32.5(13.0)
Asosa	46	27(15-75)	44/2	Berta	Muslim	5.2(7.2)
Axum	15	27(19-68)	15/0	Tigre	Coptic	6.0(0.0)
Begi	22	25(15-65)	22/0	Galla	Coptic	12.0(0.0)
Bonga	49	25(15-52)	49/0	Kaffa	Coptic	20.8(5.4)
Debre Markos	30	35(18-62)	27/3	Amhara	Coptic	28.0(15.4)
Debre Zeit	6	26(22-41)	6/0	Mixed	Coptic	20.0(6.2)
Dembidolo	34	32(17-78)	34/0	Galla	Coptic	22.2(18.5)
Gambela	42	30(16-80)	41/1	Anuak	Pagan	4.1(8.1)
Gelemso	31	21(17-37)	31/0	Galla	Muslim	24.0(0.0)
Gondar	9	34(20-51)	9/0	Amhara	Coptic	4.0(0.0)
Gore	29	26(18-72)	29/0	Galla	Coptic	25.2(27.9)
Humera	39	23(16-75)	39/0	Tigre	Muslim	13.7(9.8)
Jijiga	31	29(18-65)	27/4	Somali	Muslim	25.1(22.5)
Makale	20	28(20-66)	20/0	Tigre	Coptic	11.7(1.3)
Makane Selam	41	34(20-80)	41/0	Amhara	Coptic	6.0(0.0)
Massawa	23	20(16-52)	23/0	Tigre	Coptic	52.0(0.0)
Mizan Teferi	26	27(14-65)	25/1	Gimira	Coptic	24.0(0.0)
Mota	22	25(18-58)	22/0	Amhara	Coptic	1.7(2.6)
Waca	53	25(15-84)	53/0	Kullo	Coptic	6.8(10.0)
Yirga Alem	4	38(22-50)	4/0	Amhara	Coptic	6.0(0.0)
Total	698	26(10-99)	676/22	-	-	17.4(16.4)

[a] Range in parenthesis

[b] Primarily Amhara and Galla

Appendix Table 4. Selected population and physical data for 49 towns and villages in Ethiopia participating in human louse epidemiological surveys.

Town	Province	Estimated Population	Elevation (m)	Mean Annual Temp. (°C)	Mean Annual Precip. (mm)
Abol	Illubabor	300	530	27	800
Addis Alem	Shoa	6500	2400	16	1200
Anger Guten	Wollega	700	1430	21	1400
Arba Minch	Gemu Gofa	8100	1200	20	1000
Ariet	Illubabor	250	530	27	800
Aseita	Wollo	1000	610	27	100
Asela	Arussi	17000	2450	14	1000
Asmara	Eritrea	250000	2325	16	500
Asosa	Wollega	2200	1600	21	1400
Awo	Illubabor	250	530	27	800
Axum	Tigre	14000	2150	19	800
Begi	Wollega	2300	1650	20	1400
Bonga	Kaffa	4500	1740	17	1600
Bulcha Forest	Sidamo	250	1500	20	600
Chida	Kaffa	1000	1540	17	1200
Debre Markos	Gojjam	27000	2480	16	1400
Debre Zeit	Shoa	30000	2100	18	800
Dembidolo	Wollega	10000	1585	19	1000
Didessa	Wollega	2000	1320	21	1800
Dire Dawa	Hararge	65000	1160	26	600
Dolo	Sidamo	700	275	29	100
El Kere	Bale	500	760	27	200
Gambela	Illubabor	2500	525	27	1200
Gelemso	Hararge	5000	1840	20	1000

Appendix Table 4. Continued.

Town	Province	Estimated Population	Elevation (m)	Mean Annual Temp. (°C)	Mean Annual Precip. (mm)
Gilo	Illubabor	2000	530	27	1200
Gok	Illubabor	1000	530	27	1200
Gondar	Begemder	35000	1980	20	1400
Gore	Illubabor	3000	2005	18	2200
Harar	Hararge	50000	1855	22	670
Humera	Begemder	8000	590	28	400
Jijiga	Hararge	1500	1400	26	600
Jikau	Illubabor	1500	530	27	800
Koka	Shoa	500	1500	20	800
Lalibela	Wollo	4000	1980	20	1100
Lemi	Shoa	250	2800	13	1200
Leper Colony	Shoa	500	2400	16	1200
Makale	Tigre	30000	2130	19	600
Makane Selam	Wollo	3700	2530	15	900
Massawa	Eritrea	16000	5	30	180
Menagesha	Shoa	500	2500	15	1400
Menora	Kaffa	1500	1290	17	1600
Mizan Teferi	Kaffa	3000	1340	18	2000
Mota	Gojjam	5000	2470	15	1200
Sheik Hussein	Bale	500	1000	20	600
Tailut	Illubabor	500	530	27	800
Tepi	Illubabor	2100	1250	1[illegible]	2000
Waca	Kaffa	4000	1280	19	1200
Wollo Ferda	Shoa	250	2850	13	1200
Yirga Alem	Sidamo	14000	1700	19	1200

Appendix Table 5. Selected socioeconomic and personal hygiene data for 2359 persons sampled during 24 months in Addis Ababa, Ethiopia.

Month	N	Median Age	Sex M/F	$\overline{X}(\pm SD)$ Times Clothes Washed/yr	$\overline{X}(\pm SD)$ Times Clothes Changed/yr[b]
July 1974	47	20(12-59)[a]	32/15	32.9(19.8)	-
August 1974	45	30(12-70)	28/17	24.5(18.2)	-
September 1974	105	25(4-67)	77/28	27.9(21.0)	-
October 1974	134	28(6-70)	88/46	26.0(19.8)	-
November 1974	66	25(9-63)	36/30	28.9(20.3)	-
December 1974	103	24(6-78)	67/36	29.1(21.7)	-
January 1975	103	26(7-65)	74/29	26.2(18.6)	-
February 1975	106	25(7-60)	72/34	23.4(19.5)	-
March 1975	101	25(6-59)	67/34	22.0(17.9)	-
April 1975	110	26(5-70)	69/41	22.5(19.6)	-
May 1975	100	25(7-68)	44/56	28.9(19.4)	33.2(26.1)
June 1975	101	26(6-77)	72/29	26.1(20.8)	27.4(24.1)
July 1975	102	24(3-78)	60/42	26.6(19.5)	28.2(31.1)
August 1975	105	22(6-63)	65/40	23.2(20.5)	20.3(23.0)
September 1975	105	26(9-78)	74/31	19.8(20.5)	11.5(21.5)
October 1975	118	22(2-68)	67/51	28.1(20.7)	27.2(23.2)
November 1975	102	26(5-63)	45/57	31.9(20.2)	36.8(23.4)
December 1975	104	25(9-60)	49/55	21.6(22.2)	20.6(27.7)
January 1976	99	25(6-70)	50/49	15.9(17.7)	9.8(15.6)
February 1976	101	25(6-85)	44/57	26.6(20.6)	24.2(24.8)
March 1976	101	25(6-70)	65/36	18.8(20.1)	16.8(23.4)
April 1976	103	25(4-70)	67/36	23.6(21.3)	24.7(26.6)
May 1976	100	23(7-70)	59/41	25.4(22.4)	31.8(37.2)
June 1976	98	22(6-70)	40/58	35.1(19.2)	44.9(35.1)
Total	2359	25(2-85)	1411/948	25.4(20.5)	25.5(27.8)

[a] Range in parenthesis

[b] Data not recorded for the first ten months of the study

Appendix Table 6. Meteorological data for 24 months in Addis Ababa, Ethiopia. Figures represent monthly averages.

Month	Temperature (°C) Range[a]	Temperature (°C) Mean	Mean %RH[b]	Mean Precip. (mm)
July 1974	9.2	14.5	79	265
August 1974	8.6	14.7	80	331
September 1974	9.8	14.8	71	204
October 1974	12.1	14.9	46	4
November 1974	15.4	13.3	42	0
December 1974	19.4	14.1	41	0
January 1975	19.9	15.0	42	0
February 1975	19.0	16.6	50	3
March 1975	18.1	18.2	48	24
April 1975	16.0	17.9	59	6
May 1975	16.7	18.3	52	54
June 1975	15.9	16.1	74	124
July 1975	13.5	15.1	80	272
August 1975	6.8	15.6	86	184
September 1975	8.6	15.3	80	182
October 1975	10.9	16.0	55	17
November 1975	18.4	14.1	47	0
December 1975	18.7	14.3	44	0
January 1976	23.3	15.1	48	19
February 1976	17.5	16.9	49	61
March 1976	12.1	17.4	50	44
April 1976	11.0	16.6	58	95
May 1976	11.1	17.2	60	105
June 1976	11.3	16.1	57	109
Total	14.3	15.8	58	88

[a]Temperature range calculated as the difference between the mean maximum and minimum daily temperatures for each month.

[b]Percent relative humidity (%RH) based on an average of readings made at 0600, 1200 and 1800 hours daily.

Appendix Table 7. Mean clothes washing rates by different socioeconomic variables for Addis Ababa, 49 towns and 23 prisons.

Variable	Addis Ababa			Towns			Prisons		
	N	Mean	SD	N	Mean	SD	N	Mean	SD
Age Group									
< 1-9	88	31.5a*	19.6	367	41.0a	34.5	0	-	-
10-19	590	29.0a	21.5	701	26.9b	21.7	104	21.5a	16.8
20-29	782	25.1a	21.0	569	27.5b	23.9	311	16.5a	15.0
30-39	431	24.3a	19.2	349	27.7b	28.5	138	17.1a	17.9
40-49	268	21.0ab	18.3	210	21.9b	23.2	64	16.0a	15.8
50-59	114	24.2ab	20.0	81	22.5b	25.1	37	17.9a	18.2
60-69	79	18.8b	18.3	94	24.6b	29.0	25	16.6a	21.6
70-79+	7	20.4ab	22.1	18	31.9ab	35.9	19	17.0a	15.2
Total	2359	25.4	20.5	2389	28.7	26.7	698	17.4	16.4
Sex									
Female	948	33.8a	19.5	816	34.6a	29.0	22	34.6a	19.0
Male	1411	19.8b	19.2	1573	25.6b	25.0	676	16.9b	16.0
Total	2359	25.4	20.5	2389	28.7	26.7	698	17.4	16.4
Religion									
Coptic	1309	25.6a	21.0	1706	27.8a	23.8			
Muslim	129	20.0b	19.5	382	35.8b	35.6			
Pagan	0	-	-	201	15.5c	17.7			
Protestant	1	0.0	0.0	20	21.4ac	13.2			
Total	1439	25.1	20.9	2309	28.0	26.1			

Appendix Table 7. Continued.

Variable	Addis Ababa			Towns		
	N	Mean	SD	N	Mean	SD
Education Level						
None	1113	22.1a	20.0	762	25.3a	27.6
1-4	137	35.4bc	19.4	106	37.7b	22.7
5-8	146	33.4b	21.7	60	42.3b	16.8
9-12	43	41.9c	22.0	27	48.0b	12.2
13-16	0	-	-	1	52.0	0.0
Total	1439	25.1	20.9	956	28.4	26.9
Marital Status						
Divorced	182	27.1ab	21.1	33	28.1a	31.5
Married	563	30.2b	19.3	610	28.6a	26.0
Single	871	24.0a	21.6	967	32.2a	28.1
Widow(er)	68	24.7ab	20.0	32	22.4a	25.2
Total	1684	26.5	20.9	1642	30.6	27.4
Residence						
Rural	90	13.3a	11.2	570	17.7a	17.4
Urban	1349	25.9b	21.2	443	44.9b	31.5
Total	1439	25.1	20.9	1013	29.6	28.0
Migrant/Settled						
Migrant	310	15.3a	14.6	420	26.2a	24.0
Settled	2049	27.0b	20.8	1969	29.2b	27.3
Total	2359	25.4	20.5	2389	28.7	26.7

*Means followed by different letters are significantly different at the 5% level (Duncan's multiple range test); sample sizes less than 5 not included in the analysis.

Appendix Table 8. Codes, units of measure and normal values for the physiological variables evaluated in the hospital study.

Physiological Variable	Code	Units of Measure	Normal Values: Ethiopians[a]	Normal Values: Americans[b]
Rectal Temperature	TEMP	^oC	-	37.0
Weight	WT	kg	-	-
Height	HT	cm	-	-
Arm Circumference	ARMC	cm	-	-
Biceps Skinfold	BIC	mm	-	-
Triceps Skinfold	TRIC	mm	-	-
Subscapular Skinfold	SUBS	mm	-	-
Postprandial Blood Sugar	PPBS	mg/100ml	65-102	60-100
Blood Urea Nitrogen	BUN	mg/100ml	7-17	8-18
Creatinine	CRET	mg/100ml	-	0.6-1.2
Alkaline Phosphatase	ALKP	U/ml	0.7-3.2	0.8-2.3
Serum Glutamic Oxaloacetic Transaminase	SGOT	U/ml	-	8-33
Serum Glutamic Pyruvic Transaminase	SGPT	U/ml	-	1-36
Bilirubin (Total)	BILT	mg/100ml	0.3-1.0	0.1-1.2
Bilirubin (Direct)	BILD	mg/100ml	.04-.16	0.0-0.3
Cholesterol	CHOL	mg/100ml	-	150-250
Total Protein	TP	g/100ml	7.0-9.2	6.0-7.8
Sodium	Na	mEq/L	124-146	136-142
Potassium	K	mEq/L	3.1-6.3	3.8-5.0
Chloride	Cl	mEq/L	90-102	95-103
Carbon Dioxide	CO_2	mM/L	-	21-28
Albumin	ALB	g/100ml	3.6-5.9	3.2-5.6
Beta Globulin	BETA	g/100ml	0.4-1.0	0.5-1.1

Appendix Table 8. Continued.

Physiological Variable	Code	Units of Measure	Normal Values Ethiopians[a]	Normal Values Americans[b]
Gamma Globulin	GAMA	g/100ml	1.0-2.4	0.5-1.6
Alpha-1 Globulin	A1	g/100ml	0.1-0.4	0.1-0.4
Alpha-2 Globulin	A2	g/100ml	0.4-1.0	0.4-1.2
Calcium	Ca	mg/100ml	-	9-10.6
Phosphorus	P	mg/100ml	-	3.0-4.5
Erythrocyte Sedimentation Rate	ESR	mm/hr	-	M<15-20
				F<20-30
Hemoglobin	HGB	g/100ml	M16.0-19.2	M13.5-18.0
			F13.5-15.1	F12-16
Hematocrit	HCT	%	M45-56	M40-54
			F40-46	F38-47
White Blood Cell Count	WBC	thousand/mm^3	3.6-9.9	4.5-11.0
Platelets	PLAT	thousand/mm^3	-	150-400
Prothrombin Time	PT	seconds	11.6-14.5	12-14
Partial Thromboplastin Time	PTT	seconds	25.9-43.5	60-70
Red Blood Cell Count	RBC	million/mm^3	M5.6-6.4	M4.6-6.2
			F4.2-5.7	F4.2-5.4
Reticulocyte Count	RETC	%	-	0.5-1.5
Mean Corpuscular HGB Count	MCHC	%	32-38	32-36
Mean Corpuscular Volume	MCV	u^3	83-95	82-98
Mean Corpuscular HGB	MCH	pg	27-32	27-31
Skin pH	SKPH	-	-	4.5-5.8[c]
Skin Temperature	SKTEMP	^oC	-	-
Sweat Chloride	SWCl	mEq/L	-	4-60
Sweat Sodium	SWNa	mEq/L	-	10-80

[a]Gillum (1971)

[b]Davidsohn and Henry (1974)

[c]Behrendt and Green (1971)

Appendix Table 9. Mean values for 44 different physiological variables measured in 386 volunteers; by patient group.

Variable	CONT Group			STDY Group			Student's	
	N	Mean	SD	N	Mean	SD	t	P<
TEMP	209	36.98	0.10	164	37.98	1.12	-12.72	.001
WT	210	58.10	10.71	165	52.51	7.33	6.02	.001
HT	210	163.64	9.12	165	165.00	8.02	-1.47	NS
ARMC	210	25.65	2.75	166	23.55	2.07	8.17	.001
BIC	210	5.19	2.79	167	3.21	1.01	8.70	.001
TRIC	210	12.00	6.37	167	6.13	3.63	10.60	.001
SUBS	210	10.66	5.02	167	6.29	3.28	9.74	.001
PPBS	210	84.8	17.6	172	91.9	25.3	-3.25	.001
BUN	210	12.1	3.3	176	18.4	12.3	-7.05	.001
CRET	210	0.74	0.22	176	1.00	0.52	-6.33	.001
ALKP	210	1.92	0.68	171	2.63	1.55	-5.97	.001
SGOT	210	17.9	8.1	173	44.0	40.8	-9.04	.001
SGPT	210	9.7	16.2	116	23.8	28.2	-5.74	.001
BILT	210	0.46	0.33	172	1.55	3.01	-5.21	.001
BILD	210	0.08	0.07	173	0.63	1.57	-5.04	.001
CHOL	210	155.7	33.8	172	130.9	67.3	4.66	.001
TP	210	7.61	0.54	174	7.33	0.96	3.61	.001
Na	210	137.9	2.5	130	134.6	7.6	5.74	.001
K	210	4.15	0.40	129	4.00	0.49	3.19	.002
Cl	210	101.7	3.0	129	97.6	8.3	6.51	.001
CO_2	210	23.2	1.2	127	22.7	2.1	2.99	.003
ALB	201	3.74	0.52	127	3.15	0.62	9.18	.001
BETA	201	0.87	0.16	127	0.76	0.22	5.45	.001
GAMA	201	1.87	0.42	127	1.94	0.54	-1.41	NS

Appendix Table 9. Continued.

Variable	CONT Group			STDY Group			Student's	
	N	Mean	SD	N	Mean	SD	t	P<
A1	201	0.32	0.14	127	0.45	0.18	-7.41	.001
A2	201	0.82	0.18	127	0.97	0.25	-6.45	.001
Ca	209	9.28	0.62	123	9.22	0.89	0.80	NS
P	209	3.16	0.72	124	3.37	1.02	-2.18	.030
ESR	209	10.6	8.4	169	20.8	17.1	-7.53	.001
HGB	209	15.8	1.4	176	14.8	2.3	5.30	.001
HCT	209	47.1	4.0	176	44.6	6.6	4.62	.001
RETC	208	0.7	0.3	162	0.7	0.3	1.23	NS
WBC	209	6.43	1.91	176	8.81	3.72	-8.09	.001
PLAT	209	264.98	89.98	175	164.37	132.63	8.81	.001
PT	209	12.9	0.9	171	14.1	1.4	-9.79	.001
PTT	209	39.1	4.3	108	40.6	3.9	-3.17	.002
RBC	209	4.98	0.44	73	4.83	0.54	2.24	.026
MCHC	209	33.9	0.8	73	33.5	1.2	3.25	.001
MCV	209	95.4	7.0	73	93.0	4.6	2.84	.005
MCH	209	31.8	2.4	73	30.7	1.6	3.31	.001
SKPH	206	5.57	0.59	86	5.64	0.40	-0.99	NS
SKTEMP	69	32.16	0.96	59	33.21	1.44	-4.91	.001
SWCl	82	40.5	7.7	43	41.2	10.6	0.43	NS
SWNa	82	10.8	2.0	43	11.5	2.8	-1.65	NS

Appendix Table 10. Correlation coefficients between 44 different physiological variables and age of 386 volunteers; by patient group.

Variable	CONT Group			STDY Group		
	N	r	P<	N	r	P<
TEMP	209	-.03	NS	164	-.30	.001
WT	210	.39	.001	165	.22	.002
HT	210	.34	.001	165	.12	NS
ARMC	210	.29	.001	166	.11	NS
BIC	210	-.08	NS	167	.07	NS
TRIC	210	-.19	.002	167	.01	NS
SUBS	210	-.04	NS	167	.17	.016
PPBS	210	.25	.001	172	.02	NS
BUN	210	.15	.017	176	-.13	.041
CRET	210	.30	.001	176	-.13	.038
ALKP	210	-.15	.015	171	-.08	NS
SGOT	210	.13	.032	173	-.08	NS
SGPT	210	.08	NS	116	-.21	.011
BILT	210	-.05	NS	172	-.11	NS
BILD	210	.01	NS	173	-.12	NS
CHOL	210	.35	.001	172	.05	NS
TP	210	.17	.007	174	.11	NS
Na	210	-.18	.005	130	.08	NS
K	210	.26	.001	129	.05	NS
Cl	210	-.20	.002	129	.05	NS
CO_2	210	.15	.017	127	.03	NS
ALB	201	.16	.013	127	.06	NS
BETA	201	-.04	NS	127	.05	NS
GAMA	201	.10	NS	127	.31	.001
A1	201	-.17	.007	127	-.27	.001
A2	201	-.16	.010	127	-.13	NS
Ca	209	.02	NS	123	.05	NS
P	209	-.04	NS	124	-.03	NS
ESR	209	-.05	NS	169	.01	NS
HGB	209	.36	.001	176	-.09	NS
HCT	209	.35	.001	176	-.08	NS
RETC	208	-.13	.027	162	-.13	.049
WBC	209	.10	NS	176	-.16	.015
PLAT	209	-.01	NS	175	.23	.001
PT	209	.02	NS	171	-.12	NS
PTT	209	.03	NS	108	-.08	NS

Appendix Table 10. Continued.

Variable	CONT Group			STDY Group		
	N	r	P<	N	r	P<
RBC	209	.36	.001	73	-.05	NS
MCHC	209	.07	NS	73	.21	.040
MCV	209	-.04	NS	73	.12	NS
MCH	209	-.02	NS	73	-.02	NS
SKPH	206	-.17	.008	86	-.01	NS
SKTEMP	69	-.30	.006	59	-.40	.001
SWCl	82	-.01	NS	43	.17	NS
SWNa	82	-.06	NS	43	-.04	NS

Appendix Table 11. Mean values for 44 different physiological variables measured in 210 volunteers of the CONT Group; by sex.

Variable	Females N	Females Mean	Females SD	Males N	Males Mean	Males SD	Student's t	P<
TEMP	113	36.98	0.11	96	36.99	0.08	-0.86	NS
WT	113	53.85	9.42	97	63.04	10.01	-6.85	.001
HT	113	158.42	6.64	97	169.71	7.78	-11.34	.001
ARMC	113	24.88	2.67	97	26.54	2.59	-4.53	.001
BIC	113	6.07	2.97	97	4.15	2.15	5.29	.001
TRIC	113	15.16	6.05	97	8.31	4.50	9.17	.001
SUBS	113	11.97	5.05	97	9.14	4.55	4.25	.001
PPBS	113	83.9	12.2	97	85.8	22.3	-0.76	NS
BUN	113	11.0	3.0	97	13.4	3.2	-5.73	.001
CRET	113	0.63	0.17	97	0.86	0.21	-8.91	.001
ALKP	113	1.93	0.74	97	1.91	0.60	0.21	NS
SGOT	113	15.6	8.0	97	20.7	7.3	-4.78	.001
SGPT	113	7.8	16.2	97	11.9	16.0	-1.85	NS
BILT	113	0.43	0.33	97	0.49	0.34	-1.19	NS
BILD	113	0.07	0.05	97	0.09	0.09	-1.77	NS
CHOL	113	153.5	30.8	97	158.2	37.0	-1.00	NS
TP	113	7.58	0.57	97	7.65	0.50	-0.98	NS
Na	113	138.0	2.5	97	137.7	2.5	0.93	NS
K	113	4.09	0.37	97	4.22	0.42	-2.36	.019
Cl	113	102.1	2.9	97	101.1	3.1	2.45	.015
CO_2	113	23.1	1.2	97	23.4	1.1	-1.87	NS
ALB	106	3.67	0.54	95	3.80	0.48	-1.82	NS
BETA	106	0.89	0.16	95	0.85	0.16	1.71	NS
GAMA	106	1.84	0.44	95	1.90	0.40	-0.87	NS

Appendix Table 11. Continued.

Variable	Females N	Females Mean	Females SD	Males N	Males Mean	Males SD	Student's t	P<
A1	106	0.33	0.15	95	0.31	0.12	0.68	NS
A2	106	0.84	0.18	95	0.79	0.17	1.91	NS
Ca	113	9.28	0.61	96	9.28	0.64	-0.01	NS
P	113	3.26	0.54	96	3.04	0.87	2.20	.029
ESR	113	14.3	8.7	96	6.3	5.6	7.77	.001
HGB	113	14.9	1.0	96	16.8	1.0	-13.54	.001
HCT	113	44.6	2.8	96	50.1	3.2	-13.08	.001
RETC	112	0.7	0.3	96	0.7	0.3	0.52	NS
WBC	113	6.31	1.84	96	6.56	2.00	-0.95	NS
PLAT	113	277.70	98.13	96	250.00	77.17	2.24	.026
PT	113	13.0	0.9	96	12.9	0.9	0.80	NS
PTT	113	38.6	3.9	96	39.6	4.7	-1.81	NS
RBC	113	4.78	0.40	96	5.21	0.36	-8.26	.001
MCHC	113	33.8	0.9	96	34.0	0.8	-1.46	NS
MCV	113	94.4	6.5	96	96.7	7.3	-2.41	.017
MCH	113	31.3	2.3	96	32.3	2.5	-3.02	.003
SKPH	110	5.76	0.60	96	5.35	0.50	5.31	.001
SKTEMP	39	32.47	1.04	30	31.76	0.68	3.23	.002
SWCl	35	39.7	9.0	47	41.1	6.7	-0.80	NS
SWNa	35	11.1	2.0	47	10.5	2.0	1.36	NS

Appendix Table 12. Mean values for 44 different physiological variables measured in 176 volunteers of the STDY Group; by sex.

Variable	Females N	Females Mean	Females SD	Males N	Males Mean	Males SD	Student's t	P<
TEMP	23	37.53	0.94	141	38.05	1.14	-2.06	.041
WT	22	50.83	8.53	143	52.77	7.13	-0.81	NS
HT	22	158.17	8.23	143	166.00	7.49	-4.51	.001
ARMC	23	23.65	2.06	143	23.53	2.08	0.26	NS
BIC	24	4.45	1.51	143	3.00	0.73	7.50	.001
TRIC	24	11.16	7.08	143	5.29	1.51	8.91	.001
SUBS	24	9.57	6.63	143	5.74	1.82	5.79	.001
PPBS	24	91.0	13.6	148	92.0	26.8	-0.20	NS
BUN	24	11.4	3.4	152	19.5	12.9	-3.05	.003
CRET	24	0.66	0.30	152	1.04	0.52	-3.41	.001
ALKP	24	2.56	1.86	147	2.64	1.50	-0.24	NS
SGOT	23	19.6	10.9	150	47.7	42.4	-3.16	.002
SGPT	14	4.7	12.4	102	26.4	28.8	-2.77	.007
BILT	24	0.86	1.73	148	1.66	3.16	-1.20	NS
BILD	24	0.36	1.08	149	0.67	1.64	-0.89	NS
CHOL	23	141.4	33.5	149	129.3	71.0	0.80	NS
TP	24	7.44	0.78	150	7.31	0.98	0.61	NS
Na	17	138.9	8.9	113	134.0	7.2	2.52	.013
K	17	3.89	0.39	112	4.01	0.50	-0.91	NS
Cl	17	101.9	7.8	112	96.9	8.2	2.35	.020
CO_2	17	22.8	2.5	110	22.7	2.0	0.10	NS
ALB	17	3.50	0.52	110	3.10	0.62	2.50	.014
BETA	17	0.79	0.19	110	0.76	0.22	0.62	NS
GAMA	17	1.87	0.47	110	1.96	0.55	-0.64	NS

Appendix Table 12. Continued.

Variable	Females			Males			Student's	
	N	Mean	SD	N	Mean	SD	t	P<
A1	17	0.34	0.17	110	0.47	0.17	-2.84	.005
A2	17	0.85	0.25	110	0.99	0.25	-2.15	.034
Ca	17	8.94	0.69	106	9.26	0.91	-1.42	NS
P	17	3.40	0.83	107	3.36	1.05	0.14	NS
ESR	24	25.2	16.4	145	20.0	17.2	1.37	NS
HGB	24	14.0	1.6	152	14.9	2.3	-1.80	NS
HCT	24	42.3	4.9	152	45.0	6.7	-1.85	NS
RETC	23	0.7	0.4	139	0.6	0.3	0.52	NS
WBC	24	8.07	3.06	152	8.93	3.81	-1.05	NS
PLAT	24	219.92	114.62	151	155.54	133.49	2.23	.027
PT	24	13.5	0.8	147	14.2	1.5	-2.33	.021
PTT	14	39.9	3.5	94	40.7	4.0	-0.75	NS
RBC	13	4.49	0.44	60	4.91	0.53	-2.63	.011
MCHC	13	33.6	0.6	60	33.5	1.4	0.39	NS
MCV	13	91.0	2.4	60	93.4	4.8	-1.72	NS
MCH	13	30.0	0.6	60	30.9	1.7	-1.86	NS
SKPH	13	5.79	0.37	73	5.61	0.41	1.52	NS
SKTEMP	13	32.55	0.81	46	33.40	1.53	-1.90	NS
SWCl	13	37.9	10.3	30	42.6	10.5	-1.35	NS
SWNa	13	12.8	3.9	30	10.9	2.0	2.15	.037

Appendix Table 13. Mean values for 44 different physiological variables measured in 176 volunteers of the STDY Group; by patient subgroup.

Variable	WELL Group			LBRF Group			MISC Group			ANOVA	
	N	Mean	SD	N	Mean	SD	N	Mean	SD	F	P<
TEMP	52	37.00	0.61	71	38.79	0.85	41	37.81	0.98	72.59	.001
WT	54	53.33	7.28	70	51.06	7.01	41	53.90	7.68	2.49	NS
HT	54	164.68	9.98	70	164.45	7.31	41	166.22	6.14	0.68	NS
ARMC	54	24.02	2.12	70	23.26	1.95	42	23.43	2.15	2.19	NS
BIC	55	3.48	1.43	70	3.04	0.62	42	3.14	0.82	3.12	.047
TRIC	55	7.20	5.64	70	5.69	1.81	42	5.47	1.88	3.73	.026
SUBS	55	7.36	5.21	70	5.72	1.40	42	5.83	1.46	4.58	.012
PPBS	55	89.4	33.9	75	97.1	21.1	42	85.9	16.1	3.11	.047
BUN	55	12.3	4.0	79	24.8	15.3	42	14.4	6.2	25.02	.001
CRET	55	0.75	0.34	79	1.27	0.57	42	0.76	0.27	29.72	.001
ALKP	55	2.55	1.42	74	2.92	1.72	42	2.24	1.31	2.81	NS
SGOT	55	33.7	42.7	77	57.0	40.5	41	33.3	31.4	7.66	.001
SGPT	34	14.2	27.6	53	35.2	27.3	29	14.1	23.0	9.11	.001
BILT	54	0.81	1.46	76	2.60	4.13	42	0.60	0.42	9.07	.001
BILD	55	0.31	0.92	76	1.14	2.14	42	0.11	0.11	7.99	.001
CHOL	55	139.5	30.8	76	129.6	94.6	41	121.9	33.6	0.83	NS
TP	55	7.71	0.98	77	7.00	0.91	42	7.44	0.81	10.33	.001
Na	38	135.9	3.4	58	132.4	8.0	34	137.0	9.2	4.90	.009
K	38	4.16	0.41	57	3.90	0.53	34	3.98	0.46	3.36	.038
Cl	38	98.9	4.8	57	95.3	8.2	34	99.9	10.3	4.26	.016
CO_2	37	22.9	1.4	56	22.3	2.3	34	23.2	2.3	2.61	NS
ALB	39	3.46	0.59	54	2.88	0.58	34	3.24	0.55	12.13	.001
BETA	39	0.83	0.19	54	0.66	0.16	34	0.83	0.27	10.31	.001
GAMA	39	2.10	0.61	54	1.81	0.42	34	1.97	0.58	3.42	.036

Appendix Table 13. Continued.

Variable	WELL Group			LBRF Group			MISC Group			ANOVA	
	N	Mean	SD	N	Mean	SD	N	Mean	SD	F	P<
A1	39	0.34	0.15	54	0.57	0.14	34	0.40	0.13	33.32	.001
A2	39	0.88	0.25	54	1.06	0.22	34	0.94	0.25	6.73	.002
Ca	38	9.62	0.96	50	9.05	0.75	50	9.03	0.86	6.09	.003
P	40	3.42	0.88	49	3.09	0.98	35	3.69	1.15	3.72	.027
ESR	55	14.7	13.8	72	26.2	17.5	42	19.5	17.7	7.82	.001
HGB	55	15.4	2.4	79	14.4	2.1	42	14.7	2.2	3.60	.029
HCT	55	46.6	6.5	79	43.6	6.0	42	44.0	7.2	3.85	.023
RETC	53	0.7	0.4	68	0.6	0.3	41	0.7	0.3	1.02	NS
WBC	55	7.66	2.59	79	9.30	3.64	42	9.41	4.74	4.02	.020
PLAT	55	275.27	106.31	78	65.28	93.59	42	203.17	81.24	83.25	.001
PT	54	13.9	2.0	75	14.3	0.9	42	14.0	1.2	1.38	NS
PTT	32	38.9	3.0	48	41.2	4.5	28	41.6	2.8	4.99	.009
RBC	23	5.05	0.38	31	4.87	0.59	19	4.51	0.48	6.16	.003
MCHC	23	33.9	0.7	31	33.2	1.7	19	33.5	0.8	2.27	NS
MCV	23	93.9	5.0	31	92.8	4.6	19	92.0	4.0	0.92	NS
MCH	23	30.9	1.3	31	30.8	1.9	19	30.4	1.4	0.50	NS
SKPH	31	5.66	0.46	30	5.65	0.41	25	5.59	0.32	0.26	NS
SKTEMP	21	32.38	0.96	20	34.56	0.97	18	32.68	1.28	24.16	.001
SWCl	16	36.4	12.6	11	45.4	10.4	16	43.1	6.4	3.07	NS
SWNa	16	12.8	3.8	11	10.3	1.6	16	11.0	1.7	3.31	.047

Appendix Table 14. Correlation coefficients calculated between head louse levels and 44 different physiological variables for 119 subjects (STDY Group) and sex.

Variable	STDY Group			Males			Females		
	N	r	P<	N	r	P<	N	r	P<
TEMP	114	.13	NS	104	.16	NS	10	-.04	NS
WT	115	-.02	NS	105	.02	NS	10	-.29	NS
HT	115	.04	NS	105	.13	NS	10	.15	NS
ARMC	115	-.06	NS	105	-.06	NS	10	-.26	NS
BIC	116	.10	NS	105	.02	NS	11	.04	NS
TRIC	116	.08	NS	105	-.03	NS	11	.07	NS
SUBS	116	.00	NS	105	-.16	NS	11	.09	NS
PPBS	119	.04	NS	108	.01	NS	11	.63	.019
BUN	119	.09	NS	108	.13	NS	11	-.12	NS
CRET	119	.04	NS	108	.06	NS	11	-.06	NS
ALKP	114	.16	.046	103	.11	NS	11	.50	NS
SGOT	116	.18	.030	106	.21	.014	10	.40	NS
SGPT	65	.28	.012	64	.29	.010	1	-	-
BILT	115	.18	.029	104	.18	.034	11	.34	NS
BILD	116	.18	.028	105	.17	.038	11	.36	NS
CHOL	116	.00	NS	106	-.20	NS	10	.24	NS
TP	118	-.08	NS	107	-.07	NS	11	-.47	NS
Na	79	.08	NS	75	-.01	NS	4	.02	NS
K	79	.04	NS	75	-.01	NS	4	.59	NS
Cl	79	.05	NS	75	-.03	NS	4	-.16	NS
CO_2	78	.00	NS	74	-.04	NS	4	.50	NS
ALB	77	-.13	NS	73	-.13	NS	4	-.35	NS
BETA	77	-.06	NS	73	-.08	NS	4	-.51	NS
GAMA	77	.02	NS	73	.01	NS	4	-.14	NS

Appendix Table 14. Continued.

Variable	STDY Group			Males			Females		
	N	r	P<	N	r	P<	N	r	P<
A1	77	.05	NS	73	.02	NS	4	.22	NS
A2	77	-.06	NS	73	-.08	NS	4	-.06	NS
Ca	74	-.35	.001	70	-.36	.001	4	-.24	NS
P	74	-.06	NS	70	-.10	NS	4	.26	NS
ESR	114	.18	.031	103	.15	NS	11	.47	NS
HGB	119	-.14	NS	108	-.12	NS	11	-.48	NS
HCT	119	-.15	.050	108	-.14	NS	11	-.22	NS
RETC	111	-.15	NS	101	-.16	NS	10	-.01	NS
WBC	119	-.06	NS	108	-.06	NS	11	-.18	NS
PLAT	118	-.13	NS	107	-.13	NS	11	-.66	.014
PT	115	-.14	NS	104	-.14	NS	11	.12	NS
PTT	59	.06	NS	58	.09	NS	1	-	-
RBC	33	.12	NS	33	.12	NS	0	-	-
MCHC	33	-.16	NS	33	-.16	NS	0	-	-
MCV	33	-.32	.037	33	-.32	.037	0	-	-
MCH	33	-.20	NS	33	-.20	NS	0	-	-
SKPH	45	-.16	NS	44	-.19	NS	1	-	-
SKTEMP	26	.31	NS	26	.31	NS	0	-	-
SWCl	13	-.06	NS	13	-.06	NS	0	-	-
SWNa	13	.39	NS	13	.39	NS	0	-	-

Appendix Table 15. Correlation coefficients calculated between head louse levels and 44 different physiological variables for 119 subjects; by patient subgroup.

Variable	WELL Group			LBRF Group			MISC Group		
	N	r	P<	N	r	P<	N	r	P<
TEMP	23	.00	NS	63	.00	NS	28	.10	NS
WT	25	-.06	NS	62	-.02	NS	28	.04	NS
HT	25	.15	NS	62	.09	NS	28	-.06	NS
ARMC	25	.04	NS	62	-.11	NS	28	.00	NS
BIC	26	.20	NS	62	.06	NS	28	.13	NS
TRIC	26	.19	NS	62	.05	NS	28	.10	NS
SUBS	26	.07	NS	62	-.03	NS	28	.13	NS
PPBS	26	.02	NS	65	-.07	NS	28	.29	NS
BUN	26	.08	NS	65	.07	NS	28	-.13	NS
CRET	26	-.02	NS	65	-.02	NS	28	-.06	NS
ALKP	26	.35	.041	60	.14	NS	28	-.14	NS
SGOT	26	.04	NS	63	.13	NS	27	.35	.038
SGPT	9	.42	NS	41	.09	NS	15	.30	NS
BILT	25	.22	NS	62	.16	NS	28	.13	NS
BILD	26	.20	NS	62	.17	NS	28	.32	.049
CHOL	26	-.05	NS	63	.06	NS	27	-.12	NS
TP	26	.00	NS	64	-.13	NS	28	.11	NS
Na	12	-.26	NS	47	-.05	NS	20	.42	.032
K	12	-.17	NS	47	-.01	NS	20	.38	.050
Cl	12	-.34	NS	47	-.06	NS	20	.40	.040
CO_2	12	.17	NS	46	-.11	NS	20	.26	NS
ALB	12	.04	NS	45	-.15	NS	20	-.14	NS
BETA	12	.14	NS	45	.06	NS	20	-.08	NS
GAMA	12	-.18	NS	45	-.02	NS	20	.28	NS

Appendix Table 15. Continued.

Variable	WELL Group			LBRF Group			MISC Group		
	N	r	P<	N	r	P<	N	r	P<
A1	12	.19	NS	45	.14	NS	20	-.46	.022
A2	12	.04	NS	45	-.18	NS	20	.02	NS
Ca	12	-.32	NS	41	-.18	NS	21	-.50	.011
P	13	-.16	NS	40	-.07	NS	21	.08	NS
ESR	26	-.01	NS	60	.20	NS	28	.19	NS
HGB	26	-.08	NS	65	-.08	NS	28	-.22	NS
HCT	26	.02	NS	65	-.13	NS	28	-.24	NS
RETC	25	-.08	NS	59	-.25	.028	27	.09	NS
WBC	26	.10	NS	65	-.01	NS	28	-.23	NS
PLAT	26	-.18	NS	64	.06	NS	28	-.22	NS
PT	25	-.18	NS	62	-.01	NS	28	-.34	.037
PTT	7	.19	NS	38	.06	NS	14	.00	NS
RBC	3	-.83	NS	25	.05	NS	5	.26	NS
MCHC	3	-.90	NS	25	-.05	NS	5	-.52	NS
MCV	3	-.26	NS	25	-.45	.012	5	.30	NS
MCH	3	-.90	NS	25	-.17	NS	5	.16	NS
SKPH	6	-.54	NS	28	-.12	NS	11	-.10	NS
SKTEMP	3	.94	NS	19	.05	NS	4	.02	NS
SWC1	0	-	-	11	-.13	NS	2	-	-
SWNa	0	-	-	11	.13	NS	2	-	-

Appendix Table 16. Correlation coefficients calculated between body louse levels and 44 different physiological variables for 176 subjects (STDY Group) and sex.

Variable	STDY Group			Males			Females		
	N	r	P<	N	r	P<	N	r	P<
TEMP	164	.16	.020	141	.07	NS	23	.39	.032
WT	165	-.06	NS	143	-.05	NS	22	-.34	NS
HT	165	.11	NS	143	-.01	NS	22	-.10	NS
ARMC	166	-.04	NS	143	.00	NS	23	-.29	NS
BIC	167	-.20	.005	143	.12	NS	24	-.39	.030
TRIC	167	-.31	.001	143	-.04	NS	24	-.33	NS
SUBS	167	-.20	.004	143	.07	NS	24	-.31	NS
PPBS	172	-.04	NS	148	-.08	NS	24	.29	NS
BUN	176	.21	.003	152	.14	.042	24	.13	NS
CRET	176	.16	.020	152	.05	NS	24	.28	NS
ALKP	171	.10	NS	147	.12	NS	24	-.01	NS
SGOT	173	.22	.002	150	.14	.044	23	.53	.005
SGPT	116	.22	.010	102	.12	NS	14	.38	NS
BILT	172	.18	.010	148	.16	.026	24	.11	NS
BILD	173	.15	.028	149	.13	NS	24	.10	NS
CHOL	172	.02	NS	149	.08	NS	23	-.34	NS
TP	174	-.11	NS	150	-.10	NS	24	-.16	NS
Na	130	-.12	NS	113	-.10	NS	17	.34	NS
K	129	-.07	NS	112	-.15	NS	17	.38	NS
Cl	129	-.11	NS	112	-.10	NS	17	.39	NS
CO_2	127	-.05	NS	110	-.05	NS	17	-.06	NS
ALB	127	-.29	.001	110	-.21	.014	17	-.44	.040
BETA	127	-.11	NS	110	-.10	NS	17	-.02	NS
GAMA	127	-.03	NS	110	-.09	NS	17	.20	NS

Appendix Table 16. Continued.

Variable	STDY Group			Males			Females		
	N	r	P<	N	r	P<	N	r	P<
A1	127	.19	.017	110	.09	NS	17	.18	NS
A2	127	.16	.033	110	.09	NS	17	.18	NS
Ca	123	.00	NS	106	-.05	NS	17	-.11	NS
P	124	.00	NS	107	-.02	NS	17	.24	NS
ESR	169	.06	NS	145	.06	NS	24	.38	.032
HGB	176	-.16	.016	152	-.22	.003	24	-.38	.035
HCT	176	-.14	.032	152	-.20	.006	24	-.26	NS
RETC	162	.11	NS	139	.19	.014	23	-.17	NS
WBC	176	-.08	NS	152	-.12	NS	24	-.10	NS
PLAT	175	-.16	.018	151	-.08	NS	24	-.28	NS
PT	171	.07	NS	147	-.02	NS	24	.27	NS
PTT	108	.07	NS	94	.10	NS	14	-.41	NS
RBC	73	-.11	NS	60	-.29	.011	13	-.23	NS
MCHC	73	-.07	NS	60	-.10	NS	13	.38	NS
MCV	73	.16	NS	60	.12	NS	13	-.39	NS
MCH	73	.12	NS	60	.04	NS	13	-.18	NS
SKPH	86	-.22	.021	73	-.16	NS	13	-.25	NS
SKTEMP	59	.36	.002	46	.40	.003	13	-.51	.037
SWCl	43	.07	NS	30	.03	NS	13	-.14	NS
SWNa	43	-.05	NS	30	-.11	NS	13	.42	NS

Appendix Table 17. Correlation coefficients calculated between body louse levels and 44 different physiological variables for 176 subjects; by patient subgroup.

Variable	WELL Group			LBRF Group			MISC Group		
	N	r	P<	N	r	P<	N	r	P<
TEMP	52	.13	NS	71	.13	NS	41	.28	.040
WT	54	.09	NS	70	.00	NS	41	-.17	NS
HT	54	.29	.017	70	.12	NS	41	-.28	.041
ARMC	54	-.05	NS	70	.00	NS	42	.08	NS
BIC	55	-.19	NS	70	-.14	NS	42	-.11	NS
TRIC	55	-.33	.007	70	-.29	.008	42	-.26	.046
SUBS	55	-.19	NS	70	-.14	NS	42	-.18	NS
PPBS	55	-.21	NS	75	-.03	NS	42	.18	NS
BUN	55	.34	.006	79	.08	NS	42	.03	NS
CRET	55	.01	NS	79	-.04	NS	42	.24	NS
ALKP	55	-.01	NS	74	.10	NS	42	.10	NS
SGOT	55	.21	NS	77	.04	NS	41	.30	.030
SGPT	34	.25	NS	53	-.20	NS	29	.39	.018
BILT	54	.01	NS	76	.18	NS	42	.16	NS
BILD	55	.00	NS	76	.14	NS	42	.25	NS
CHOL	55	-.23	.043	76	.18	NS	41	-.12	NS
TP	55	-.13	NS	77	.01	NS	42	.11	NS
Na	38	-.14	NS	58	-.17	NS	34	.08	NS
K	38	.05	NS	57	-.20	NS	34	.15	NS
Cl	38	-.08	NS	57	-.23	.045	34	.10	NS
CO_2	37	-.05	NS	56	-.06	NS	34	.11	NS
ALB	39	-.48	.001	54	.11	NS	34	-.22	NS
BETA	39	-.14	NS	54	-.01	NS	34	.15	NS
GAMA	39	.16	NS	54	-.18	NS	34	.04	NS

Appendix Table 17. Continued.

Variable	WELL Group			LBRF Group			MISC Group		
	N	r	P<	N	r	P<	N	r	P<
A1	39	.20	NS	54	-.25	.034	34	.10	NS
A2	39	.12	NS	54	-.14	NS	34	.29	.050
Ca	38	.20	NS	50	-.04	NS	35	-.05	NS
P	40	.23	NS	49	-.24	.046	35	.15	NS
ESR	55	.05	NS	72	-.06	NS	42	-.06	NS
HGB	55	-.37	.003	79	-.04	NS	42	.19	NS
HCT	55	-.32	.008	79	-.05	NS	42	.16	NS
RETC	53	.32	.010	68	.00	NS	41	.00	NS
WBC	55	-.15	NS	79	-.23	.021	42	-.01	NS
PLAT	55	-.03	NS	78	.15	NS	42	.05	NS
PT	54	.05	NS	75	-.12	NS	42	.20	NS
PTT	32	-.02	NS	48	.08	NS	28	-.06	NS
RBC	23	-.25	NS	31	-.31	.046	19	.25	NS
MCHC	23	.20	NS	31	-.01	NS	19	.09	NS
MCV	23	.43	.019	31	-.22	NS	19	.47	.021
MCH	23	.35	NS	31	-.29	NS	19	.54	.008
SKPH	31	-.13	NS	30	-.50	.003	25	-.23	NS
SKTEMP	21	-.43	.026	20	.21	NS	18	.43	.038
SWC1	16	.05	NS	11	-.32	NS	16	-.32	NS
SWNa	16	.05	NS	11	.18	NS	16	.46	.038

Appendix Table 18. Results of stool examinations for 364 subjects showing prevalence rates of 14 intestinal parasites in two patient groups.

Parasite	CONT Group			STDY Group		
	Male	Female	Total	Male	Female	Total
Ascaris lumbricoides	14(15.0)[a]	12(10.9)	26(12.8)	49(35.0)	11(52.4)	60(37.3)
Trichuris trichiura	6(6.4)	18(16.4)	24(11.8)	33(23.6)	2(9.5)	35(21.7)
Strongyloides stercoralis	9(9.7)	1(0.9)	10(4.9)	28(20.0)	0	28(17.4)
Ancylostoma, Necator[b]	1(1.1)	4(3.6)	5(2.5)	15(10.7)	0	15(9.3)
Enterobius vermicularis	0	0	0	5(3.6)	0	5(3.1)
Taenia saginata	1(1.1)	1(0.9)	2(1.0)	18(12.9)	2(9.5)	20(12.4)
Hymenolepis nana	0	0	0	1(0.7)	0	1(0.6)
Schistosoma mansoni	1(1.1)	1(0.9)	2(1.0)	3(2.1)	0	3(1.9)
Entamoeba histolytica	2(2.2)	2(1.8)	4(2.0)	1(0.7)	1(4.8)	2(1.2)
Giardia lamblia	0	1(0.9)	1(0.5)	2(1.4)	1(4.8)	3(1.9)
Iodamoeba buetschlii	0	5(4.6)	5(2.5)	2(1.4)	0	2(1.2)
Isospora hominis	0	3(2.7)	3(1.5)	1(0.7)	0	1(0.6)
Entamoeba coli	20(21.5)	21(19.1)	41(20.2)	23(16.4)	5(23.8)	28(17.4)
Shigella flexneri	0	0	0	1(0.7)	0	1(0.6)
Total Patients[c]	93	110	203	140	21	161

[a]Number of isolations (percent of total patients infested)

[b]Hookworms not identified to species; see Armstrong and Chane (1975)

[c]Includes all patients examined for each group

Appendix Table 19. None, single, double and multiple infestations with intestinal parasites summarized for 364 individuals in two patient groups.

No. Different Parasites	CONT Group				STDY Group			
	Male	Female	Total	% of Total	Male	Female	Total	% of Total
0	47	56	103	50.7	34	3	37	23.0
1	40	44	84	41.4	54	14	68	42.2
2	4	7	11	5.4	32	4	36	22.4
3	2	2	4	2.0	18	0	18	11.2
4	0	0	0	-	1	0	1	0.6
5	0	1	1	0.5	0	0	0	-
6	0	0	0	-	1	0	1	0.6
Total	93	110	203	100.0	140	21	161	100.0

HUMAN LOUSE FIELD SURVEY

CODE NO.__________

Entomology Division NAMRU-5 Ethiopia

Town __________ Province __________ Date __________ 197 ____

Survey Location: Clinic _____ Prison _____ School _____ Other __________

A. PERSONAL DATA

1. Age _____
2. Male _____ Female _____
3. Tribe __________
4. Religion __________
5. Education __________
6. Marital status: Married _____ Single _____ Divorced _____ Widow(er) _____
7. Occupation: None _____ Beggar _____ Clerical _____ Craftsman _____ Farmer _____ Herdsman _____ Housewife _____ Laborer _____ Merchant _____ Servant _____ School _____ Teacher _____ Priest _____ Prisoner _____ Prostitute _____ Other _____
8. Residence status: Permanent _____ Migrant _____ How long: ___/(Dy) (Wk) (Mn) (Yr)
9. Residence location: Town _____ Country _____ Prison _____ Other _____
10. Type of housing: Tukul _____ Shack _____ House _____ Church _____ Dorm _____ Prison _____ Hotel _____ Tent _____ Verandah _____ Other _____
11. Sleeps with how many other people: _____

B. PERSONAL HYGIENE HABITS

1. Clothes washed: _____ /Never _____ /Week _____ /Month _____ /Year
2. Agent used: Soap _____ Cold water _____ Hot water _____ Other _____
3. Freq. change clothes: _____ /(Wk) (Mn) (Yr) _____
   (Clothes now are relatively: Clean _____ Dirty _____ Filthy _____)
4. Type clothes worn: Traditional _____ Western _____ Both _____ Other _____
5. Describe use of body/hair dressings __________

C. INSECTICIDE USE HISTORY

1. None used _____ DDT _____ Lindane _____ Malathion _____ Other _____
2. Freq: _____/(Wk) (Mn) (Yr) 3. Where obtained: MES _____ PHARM _____ PHD _____ Other _____
4. Personal use _____ Home use _____ Both _____ Other _____

D. HUMAN LOUSE COUNTS

1. Body lice _____ Eggs present: Yes ( ) No ( ) If yes: viable _____ hatched _____
2. Head lice _____ Eggs present: Yes ( ) No ( ) If yes: viable _____ hatched _____
3. Head hair: Shaved _____ Cut short _____ Normal _____ Plaited _____ Dressing _____ Other _____

E. Describe customs or folklore associated with lice and methods used to remove or control lice:

F. INVESTIGATOR(S): 1. Aklilu _____ 2. Negash _____ 3. Sebahtu _____ 4. Holloway _____ 5. Sholdt _____

Appendix Figure 1. Epidemiology field survey questionnaire.

Form E

LOUSE HOST PHYSIOLOGY STUDY
PHYSICAL EXAM WORKSHEET

Patient .... Code No. ....

Bed No. .... Hosp. No. .... Date ....

1. HAIR:

Lack of Luster ....
Thin ....
Coarse ....
Sparse ....
Dense ....
Friable ....
Dyspigmentation ....
Easy Pluckability ....
Other ....

2. EYES:

Conjunctival Pallor ....
Conjunctival Dryness ....
Bitit's Spots ....
Keratomalacia ....
Angular Palpebritis ....
Orbital Tension ....
Fundis Description ....

....

3. MOUTH

Lips: Angular Stomatitis ....
Angular Scars ....
Cheilosis ....

Tongue: Edema ....
Scarlet Tongue ....
Raw ....
Magenta Tongue ....
Atrophic Papillae ....
Geographic ....
Glossitis ....

Teeth: Mottled ....
Enamel Erosion ....
Enamel Hypoplasia ....
Carries ....
Missing Teeth ....

Gums: Bleeding ....
Hyperplasia ....
Pyorrhoea ....
Recession ....
Other ....

....

4. SKIN:

Texture: Oily ....
Dry ....
Turgor : Increased ....
Decreased ....
Petechiae ....
Bruisability ....
Dyspigmentation ....
Follicular Hyperkeratosis:
Type 1 ....
Type 2 ....
Dermatosis Description:

....

....

Nails Description:

....

....

5. GLANDS:

Adenopathy and Type:
Cervical ....

....

Supraclavicular ....

....

Axillary ....

....

Parotid ....

....

Inguinal ....

....

Thyromegaly ....

....

6. CARDIOVASCULAR:

Cardiomegaly ....
Murmurs Description:

....

....

Resting Pulse ....
Sitting B/P (Rt. Arm) ....

....

....

....

....

Appendix Figure 2. Physical examination worksheet.

PHYSICAL EXAM (Page 2)

7. ABDOMEN:

Distension

Spleen Size

Liver Size

Soft

Rigid

Bowel Sounds: Present Absent

Hernia - Describe:

Other:

Genitalia - Describe:

8. RECTAL EXAM:

Describe:

9. CNS:

Mental Confusion

Motor Weakness and Sensory Loss Location

Deep Tendon Reflex:

Upper Extreme

Lower Extreme

Calf Tenderness

Gait - Describe

Pathological Reflexes:

10. LOWER EXTREMITIES:

Edema, Type and Location:

Pulsations:

11. MUSCULOSKELETAL:

Cranial Bossing:

Frontal

Parietal

Costochondral Beading

Thorax Deformity - Describe:

Genu Valgum

Genu Varum

Joint Enlargement

Bone or Joint Tenderness

Skeletal Deformities:

12. LUNGS:

13. OTHER:

IMPRESSIONS AND COMMENTS ON ABOVE POSITIVE FINDINGS:

Appendix Figure 2. Continued.

LOUSE HOST PHYSIOLOGY STUDY

Entomology Division NAMRU-5 Ethiopia

Form D

Patient ____________ Code No. ____________

Bed No. ____________ Date Adm. ____________

Hosp. No. ____________ Date of Exam. ____________ Date Dis. ____________

ADMISSION DIAGNOSIS ____________

SIGNIFICANT PAST MEDICAL HISTORY ____________

CHIEF COMPLAINTS AND DURATION ____________

PRIOR RX ____________

MENSES: Regularity ____________ Amount ____________

Duration ____________ Other ____________

GENERAL IMPRESSION: Well Nourished ______ Well Developed ______ Cooperative ______

Poorly Nourished ______ Poorly Developed ______ Irritable ______

Distressed ______ Stable ______ Other ______

BUILD: Slender ______ Medium ______ Heavy ______ Obese ______

SUMMARY OF CLINICAL AND EXAMINATION FINDINGS

1. HAIR	—Normal	—Abnormal	7. ABDOMEN	—Normal	—Abnormal
2. EYES	—Normal	—Abnormal	8. RECTAL	—Normal	—Abnormal
3. MOUTH	—Normal	—Abnormal	9. CNS	—Normal	—Abnormal
4. SKIN	—Normal	—Abnormal	10. LWR EXTRMS	—Normal	—Abnormal
5. GLANDS	—Normal	—Abnormal	11. MUSCSKLN	—Normal	—Abnormal
6. CARDVASR	—Normal	—Abnormal	12. OTHER		

SKIN DISEASES: ____________ None ____

MALNUTRITION SIGNS: ____________ None ____

PATHOLOGICAL SIGNS: ____________ None ____

PYSCHOLOGICAL DISTURBANCES: ____________ None ____

OTHER: ____________

PHYSICIAN'S GENERAL IMPRESSIONS AND COMMENTS: ____________

DEFINITIVE DIAGNOSIS: ____________

Examining Physician ____________

Appendix Figure 3. Patient health assessment report form.

LOUSE HOST PHYSIOLOGY STUDY

Entomology Division NAMRU-5 Ethiopia

Form C

Patient ______________ Code No. ______________

Bed No. ______________ Hosp. No. ______________ Date ______________

Diagnosis ______________ Length of Illness ______________

A. CLINICAL CHARACTERISTICS

1. TEMP (Rec) ________ °C 2. PULSE ________ 3. B/P (RT/SIT) ________
4. CHEST X-RAY: POS ___ NEG ___ DIAG ________ 5. TB TEST: POS ___ NEG ___

B. ANTHROPOMETRIC MEASUREMENTS

1. WT ________ 1b ________ kg 2. HT ________ in ________ cm 3. ARM CIRCUM ________ cm
4. BIC ________ mm 5. TRIC ________ mm 6. SUBSCAP ________ mm

C. URINALYSIS

1. PH ________ 2. S.G. ________ 3. GLUCOSE ________
4. PROTEIN ________ mgm/100 ml 5. WBC/hpf ________ 6. OTHER ________

D. BLOOD CHEMISTRY

1. PPBS ________ mg/100 ml 6. SGPT ________ U/ ml
2. BUN ________ mg/100 ml 7. BIL (T) ________ mg/100 ml
3. CREAT ________ mg/100 ml (DIR) ________ mg/100 ml
4. ALK P ________ U/ ml 8. CHOLS ________ mg/100 ml
5. SGOT ________ U/ ml 9. T PROTEIN ________ gm/100 ml
10. Na ________ mEq/L K ________ mEq/L
Cl ________ mEq/L CO_2 ________ mM/L
11. Alb ________ % ________ gm/100 ml A1 ________ % ________ gm/100 ml
A2 ________ % ________ gm/100 ml Beta ________ % ________ gm/100 ml
Gamma ________ % ________ gm/100 ml 13. P ________ mg/100 ml
12. Ca ________ mg/100 ml

E. HEMATOLOGY

1. ESR ________ mm/hr 6. PLATELETS ________ /mm³
2. HGB ________ gm/100 ml 7. BLOOD GROUP & TYPE ________
3. HCT ________ % 8. PT ________ sec CONT ________ sec
4. RETIC ________ /1000 cells 9. PTT ________ sec CONT ________ sec
5. WBC ________ SEG ________ LYMPH ________ BAND ________ EO ________ MONO ________
10. RBC ________ MCHC ________ % MCV ________ u³ MCH ________ uugm

F. PARASITOLOGY

1. STOOL (O&P) ________ 3. MALARIA SMEAR ________
2. STOOL DESCRIPTION ________ 4. SPIR DENS ________

G. BACTERIOLOGY — SKIN MICROFLORA

1. NECK REGION ________
2. WAIST REGION ________
3. LEG REGION ________

H. SKIN pH/TEMP

1. NECK ________ / ________ °C 2. WAIST ________ / ________ °C
3. LEG ________ / ________ °C 4. AVERAGE OF READINGS ________ / ________ °C

I. SWEAT CHLORIDES ________ (mEq/L) LOCATION ________

J. COMMENTS:

____
____
____
____

Appendix Figure 4. Patient laboratory test form.

LOUSE HOST PHYSIOLOGY STUDY

FORM B

Entomology Division NAMRU-5 Ethiopia

Patient ____________ Code No. ____________

Bed No. ____________ Date ____________

A. PERSONAL DATA

1 Age ____________
2. Sex ____________
3. Tribe ____________
4. Religion ____________
5. Education ____________
6. Marital Status ____________

7 Occupation: Type ____________ How Long ____________ Where ____________

8. Estimated income level: ____________

9. Residence status: Permanent ____________ Migrant ____________ How long ____________

If migrant, from where originally: ____________

10. Residence location: ____________

11. Describe housing: ____________

12. Sleeps with how many others: ____________ Conditions ____________

13. Are other occupants: Louse infested — Yes ( ) No ( ) Sick — Yes ( ) No ( ) ____________

14. Visited outside Addis last 4 weeks: Yes ( ) No ( ) If yes, where: ____________

B. PERSONAL HYGIENE HABITS

1 Frequency clothes are washed: ____________

2. Agent used: Soap ________ Cold water ________ Hot water ________ Other ________

3. Clothes washed where: ____________

4. Freq. change clothes: ____________ 5. Type clothes worn: ____________

6. Are clothes changed at night for sleeping: Yes ( ) No ( ) ____________

7. Condition of clothes now: ____________

8. Were clothes washed or changed prior to visit to clinic: Yes ( ) No ( ) ____________

9. Freq. body washed: ____________ 10. Agent used: Soap ________ Water ________ Other ________

11. Where washed: ____________

12. How often is: Head shaved ____________ Pubic region shaved ____________

C. INSECTICIDE USAGE

1. None used ________ 2. DDT ________ Lindane ________ Malathion ________ UNK ________ Other ________

3. Freq: ____________ 4. Where obtained: ____________

5. Used for what insects: ____________ 6. Effectiveness: ____________

7. Personal use: ____________ Home use ____________ Both ____________

8. Does MES spray residence: Yes ( ) No ( ) If yes, how often: ____________

D. MISCELLANEOUS

1. Describe any use of body or hair dressings: (None—)

2. Describe any use of plant toxicants for louse control: (None—)

3. Describe any efforts to remove lice mechanically or eliminate them by physical destruction: (None—)

4. Describe any superstitions, customs, or habits related to lice: (None—)

E. INVESTIGATOR(S): 1. Aklilu— 2. Negash— 3. Sebahtu— 4. Holloway— 5. Sholdt—

Appendix Figure 5. Epidemiology hospital study questionnaire.

LOUSE HOST PHYSIOLOGY STUDY

FORM A

Entomology Division NAMRU-5 Ethiopia

Patient ______________ Code No. ______________

Bed No. ______________ Date ______________

A. BODY LOUSE DATA

1. Estimate of louse numbers: Adults ______________ Nymphs ______________ Both ______________
2. Actual louse numbers and location:

Clothing		Adults	Nymphs	Eggs	Primary locations
Underwear					
Pants					
Undershirt					
Shirt					
Shirt					
Sweater					
Coat					
Shamma					

TOTALS: Adults ______________ Nymphs ______________ Both ______________

3. Other ectoparasites present: Fleas ______________ Bed Bugs ______________ Mites ______________

B. HEAD LOUSE DATA

1. **Head Hair:**
   a. Weight ______________ gms b. Length C ______________ T ______________ Q ______________
   c. Diameter: Mean ______________ Range ______________
   d. Condition: Normal ______________ Short ______________ Shaved ______________ Plaited ______________ Dressing ______________
   e. Describe type of hair: ______________

2. **Louse Numbers:**
   a. Adults ______________ ______________ ______________ Nymphs ______________ Eggs ______________
   b. Body lice present: Yes ( ) No ( ) ______________ Adults ______________ Nymphs ______________
   c. Primary location of lice: ______________

C. CRAB LOUSE DATA

1. Louse numbers and locations:
   a. Adults ______________ Nymphs ______________ Eggs ______________
   b. Locations: Pubic area ______________ Perianal ______________ Other ______________
   c. Pubic hair is: Normal ______________ Short ______________ Shaved ______________
   d. Describe condition of hair: ______________

Appendix Figure 6. Standard form for reporting louse counts.

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